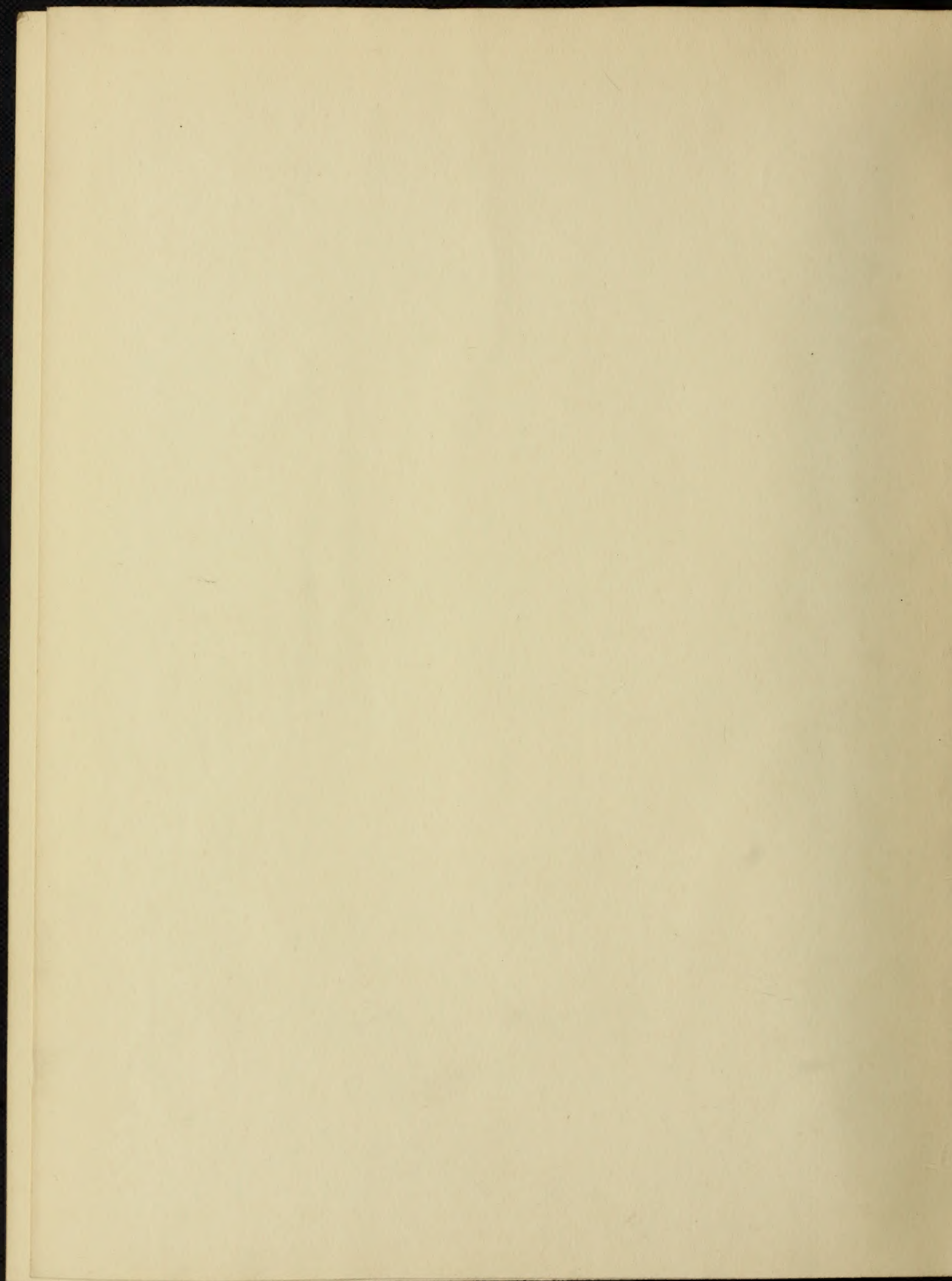


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A STUDY OF THE ECOLOGY AND REACTIONS
OF FOUR SPECIES OF ACRIDIDAE

BY

HARRY LEE ANDREWS

A.B. University of Illinois, 1916

THESIS

Submitted in Partial Fulfillment of the Requirements for the

Degree of

MASTER OF ARTS

IN ZOOLOGY

IN

THE GRADUATE SCHOOL

OF THE

UNIVERSITY OF ILLINOIS

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UNIVERSITY OF ILLINOIS
THE GRADUATE SCHOOL

Dec. 15 1917.

I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPER-
VISION BY Harry Lee Andrews.

ENTITLED A Study of the Ecology and Reactions
of Four Species of Acrididae.

BE ACCEPTED AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE
DEGREE OF Master of Arts.

Victor E. Shelford

In Charge of Thesis

Henry Ward

Head of Department

Recommendation concurred in:*

Committee

on

Final Examination*

*Required for doctor's degree but not for master's.

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UNIVERSITY OF ILLINOIS
THE GRADUATE SCHOOL

Feb 1917

I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPER-

VISION BY Henry Lee Robinson

FOR THE DEGREE OF Doctor of Philosophy

IN THE DEPARTMENT OF Geology

BE ACCEPTED AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF Master of Science

Walter C. Calkins
In Charge of Thesis

Edward H. Mearns
Head of Department

Recommendation recorded in 7

Committee }
or
Final Examination

Approved by a majority of the faculty of the Graduate School

1518

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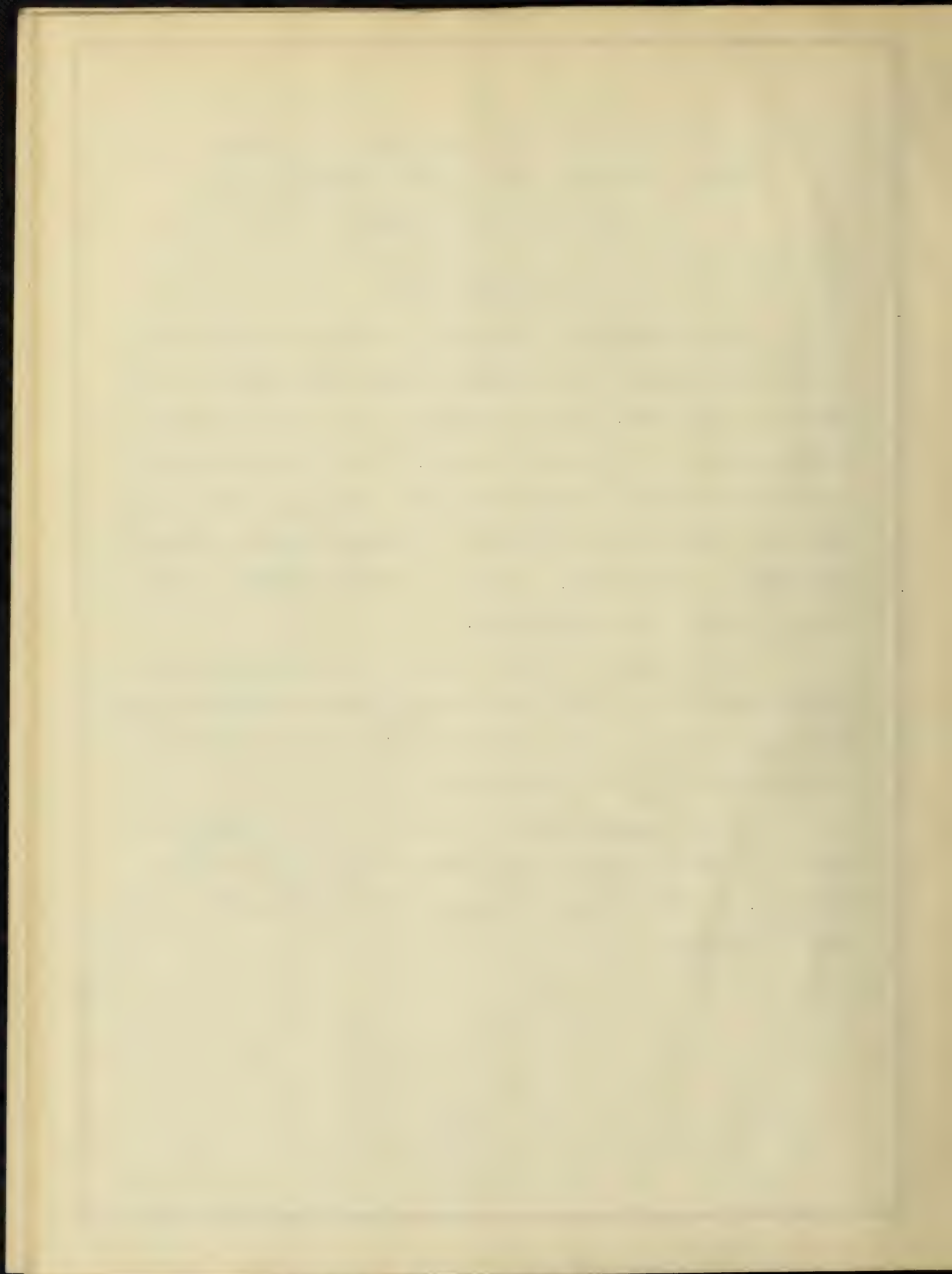
A STUDY OF THE ECOLOGY AND
REACTIONS OF FOUR SPECIES
OF ACRIDIDAE.

I. INTRODUCTION.

The material here presented is based on field observations and laboratory study during the past two summers on four species of Acrididae. In an attempt to make a census of the animal population of a plot of ground, my attention was called to the predominance of Orthopteran life. Field observations revealed not only variety in species and predominance in number of individuals of this order, but also a tendency towards segregation of species into associations.

Many attempts have been made in connection with taxonomic papers to list Orthoptera according to the vegetation upon which they are found, and to explain their distribution in terms of the distribution of their food plants.

It is the purpose of this paper to call attention to some environmental relations of greater ecological importance than food, those accounting for the formation of associations in terms of behavior.



II. LOCALITIES STUDIED.

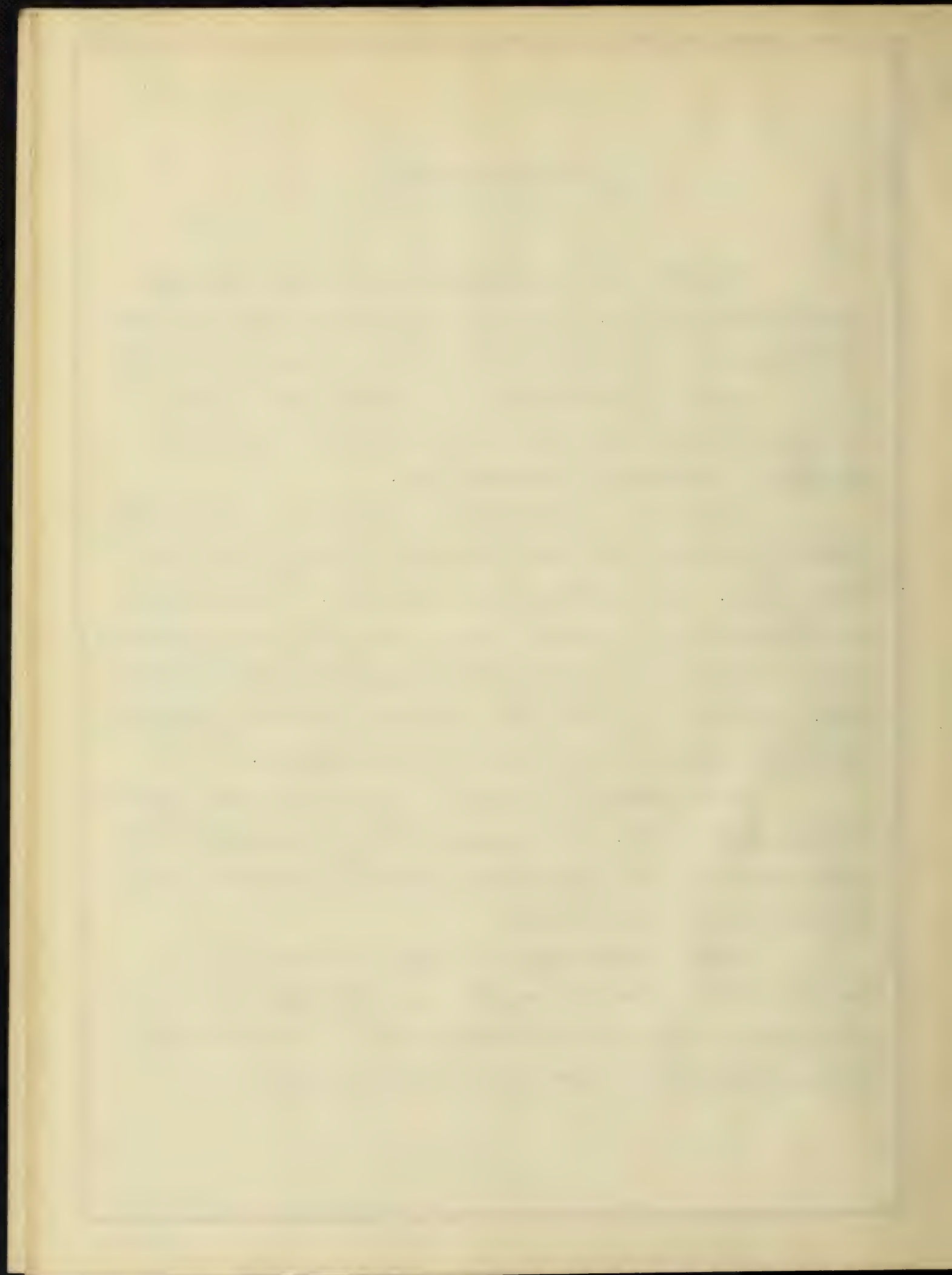
The area studied is located one mile north of Urbana along a drainage ditch. The soil is clay having been placed there in the digging of the ditch. Four distinct stations were studied.

First, the brook margin or a narrow strip of land bordering the creek supported a luxuriant growth of willows, smart-weed, cockle-burrs and water grass.

Second, the clay bank which consisted of a rather steep slope at the base of which was a regular incline adjoining the brook margin. The vegetation here was sparse. An occasional wild lettuce plant, a scrubby growth of rag-weed, and now and then a small patch of rather dwarfed white clover struggled for existence. Near the top of the steep slope was overhanging sod and an occasional piece had moved down the bank by slumping.

Third, the top of the bluff or the sweet clover association was almost level. On the ground stratum was largely blue-grass supporting also a rank upper growth of sweet clover, wild lettuce, burdocks and thistles.

Fourth, farther down at a turn in the stream was a temporary marsh or mud bank exposed only at low water, and hence supporting no vegetation except water grass. Here much debris and sediment had been deposited by occasional floods.

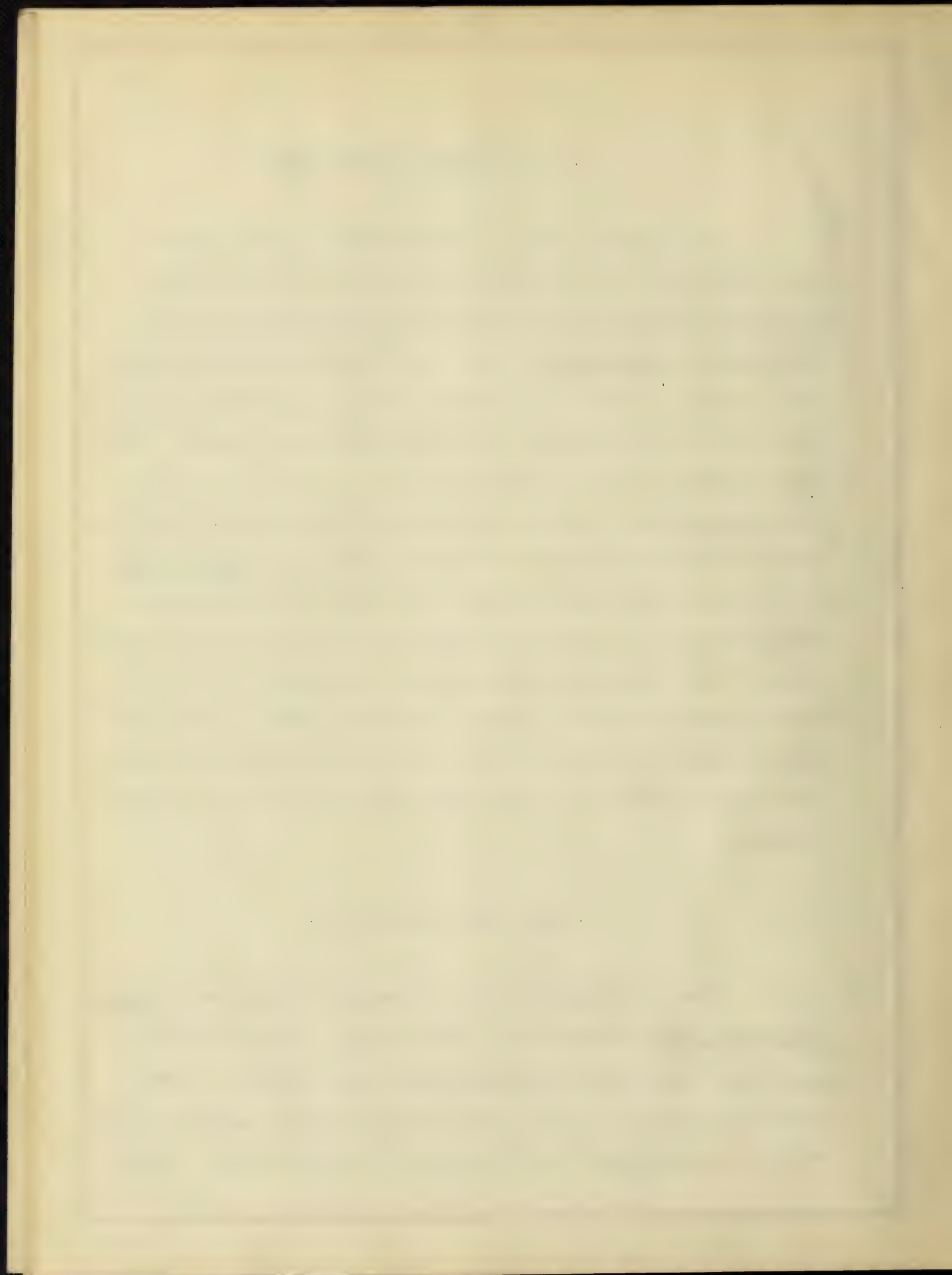


1. Brook Margin Association.

Each region had its predominating species. On the brook margin were found nymphs of all sizes and adults of Melano-lus differentialis. Besides M. differentialis was an occasional M. bivittatus, a few forked tailed katydids (Leucoderia furcata), a few short horned locusts (Orphocolla speciosa), and the short winged green locust (Dichromorpha viridis). The dense growth and moist ground formed a good habitat. The M. differentialis were by far in the majority in numbers. The above named varieties were found occasionally while M. differentialis were on every stem. The nymphs chose the ground stratum and flat leaf surfaces, while the adults were perched on the largest stems. When frightened they moved to the opposite side of the stems, usually flying to another stem about three or four feet away then dropping into the tall grass and becoming concealed. They are poor flyers usually moving by combination of jump and flight.

2. Clay-Bank Association.

The clay bank had its distinctive population. Dissosteira carolina predominated. A few locusts (Trinidia fenestralis) were observed in this habitat. Their yellowish color closely resembling the clay background afforded excellent protection. D. carolina seem to collect in small groups. While

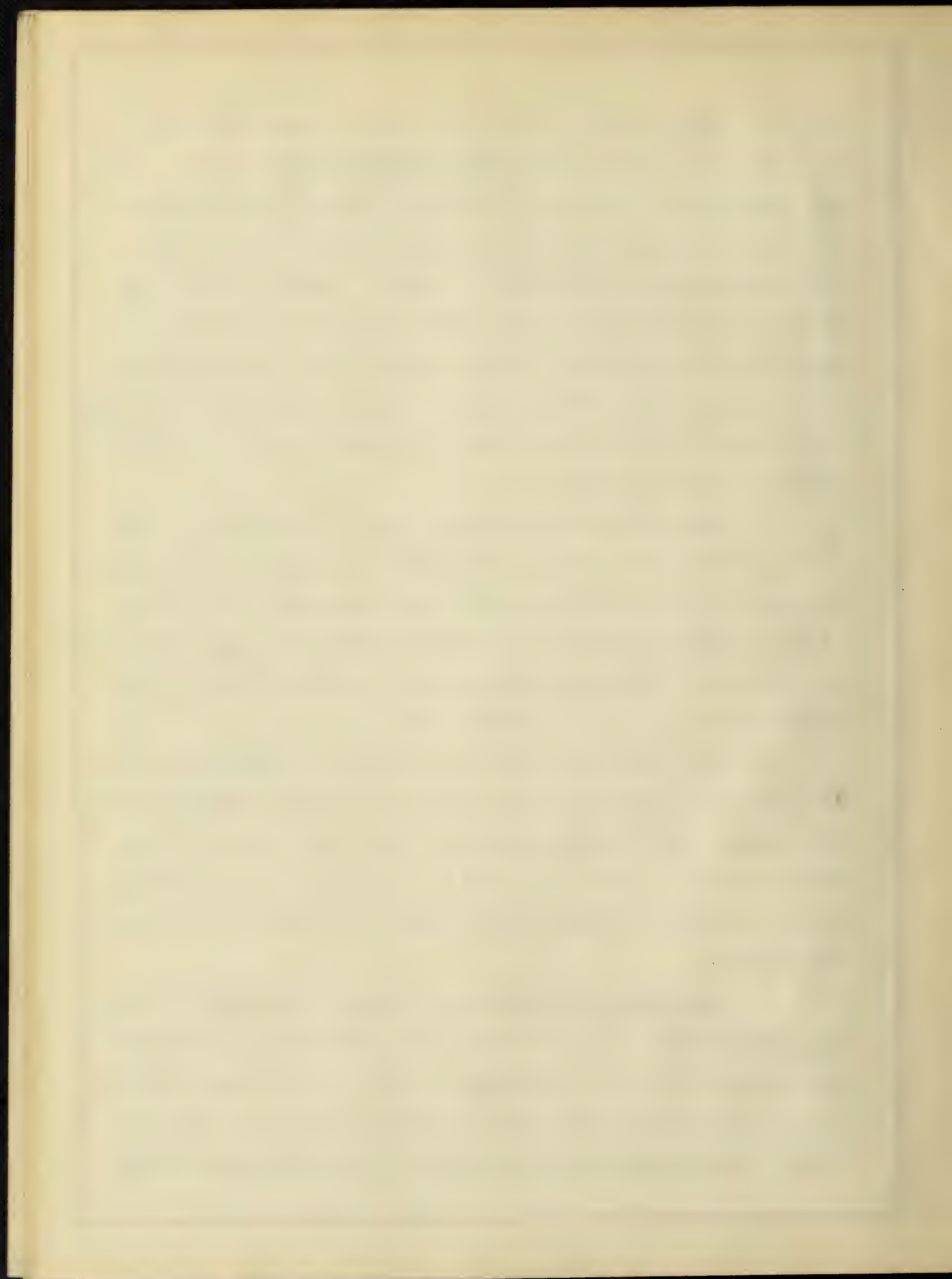


catching them for study in the laboratory, I found that from three to five, sometimes eight were usually near together. When one flew up on my approach, the others seemed to take warning, the others following closely the flight of the first to a distance sometimes ten feet away or further. When in pairs they do not fly such great distances when pursued as when alone. The females are more solitary than the males. Observing several of these small groups, I found them to contain all males. This and other observations, I am inclined to believe that the males are somewhat more gregarious.

When any object approaches they fly up alighting only a few feet away with head pointing toward the approaching danger. If danger follows they fly greater distances, each time flying higher alighting a much greater distance away. D. carolina make much less resistance when captured than the other forms. They seldom emit the so called "tobacco juice."

I observed one male making a rather spectacular flight. It flew upwards about six feet and rapidly vibrating its wings it was able to remain almost stationary for a few seconds. I observed others in such flights but were unable to capture them in order to determine whether the movements were made by both males and females.

Diastatira carolina have very good eyesight for seeing objects ahead or at the side. They are able to distinguish objects approaching at a distance of ten or twelve feet. On one occasion a large burdock quite concealed me from the locusts view. I approached sufficiently close to have captured it with

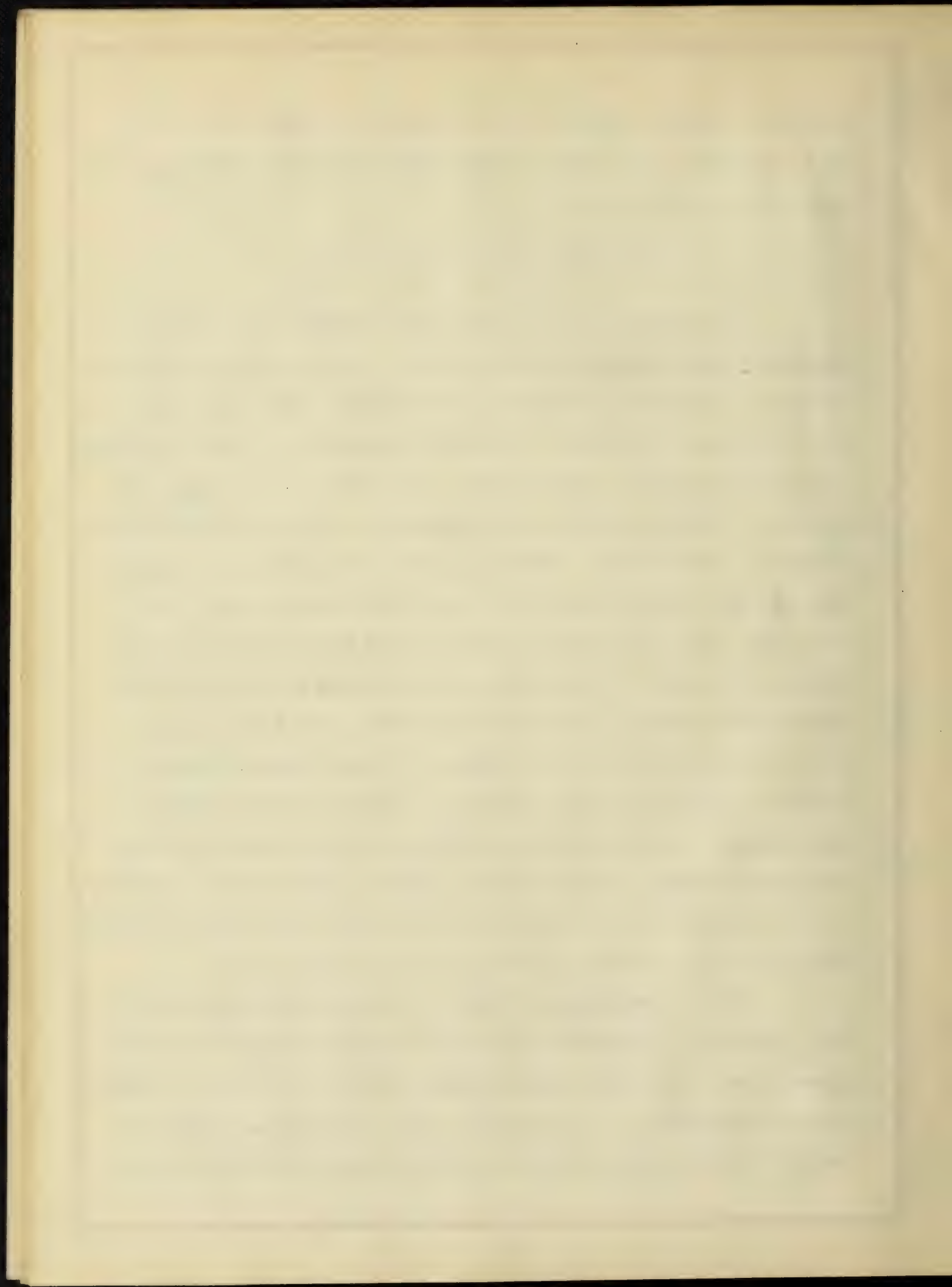


my hand. Another instance one alighted in a gully, alighting head downward on the slope. I was able to approach within two feet without being seen.

5. Sweet Clover Association.

In the sweet clover association nymphs and adults of Melanoplus femur rubrum were in excess. A sweep of the net would capture an occasional cone-head (*Conecephalus robustus*), and a few forked-tailed katydids (*Scudderia furcata*). I also found one oblong winged katydid (*Amblycorpha oblongifolia*). M. femur rubrum were in great majority. The nymphs by hundreds populated the ground and lower strata. Medium sized nymphs were more venturesome and were usually found on plants that were one-half to a foot high. They were most numerous on the broad leaves of the thistle. The adults were usually on the stems in the very tall sweet clover plants. They were very timid, and upon approach took the opposite side of the stems. Testing them with crude devices in the field, I am inclined to believe that M. femur rubrum depend much upon eyesight rather than hearing to tell the approach of danger. If approached directly from the side or above, they fly when one is within four or five feet, but when approached from below it is an easy matter to collect them by hand.

It is interesting to watch their methods of alluring their pursuers. Frequently, they will jump and proceed by flying a yard or two to another plant. They at once try to conceal themselves by crawling to the opposite side of the stem. Many times they will drop to the ground and by crawling a short distance in



the grass are safely concealed. In case they are discovered in this hiding place, it is interesting to note how easily they are captured. They seldom make any attempt to escape, and remain quiet until picked up. As soon as danger has passed, they crawl to the nearest plant and are seen in their former positions.

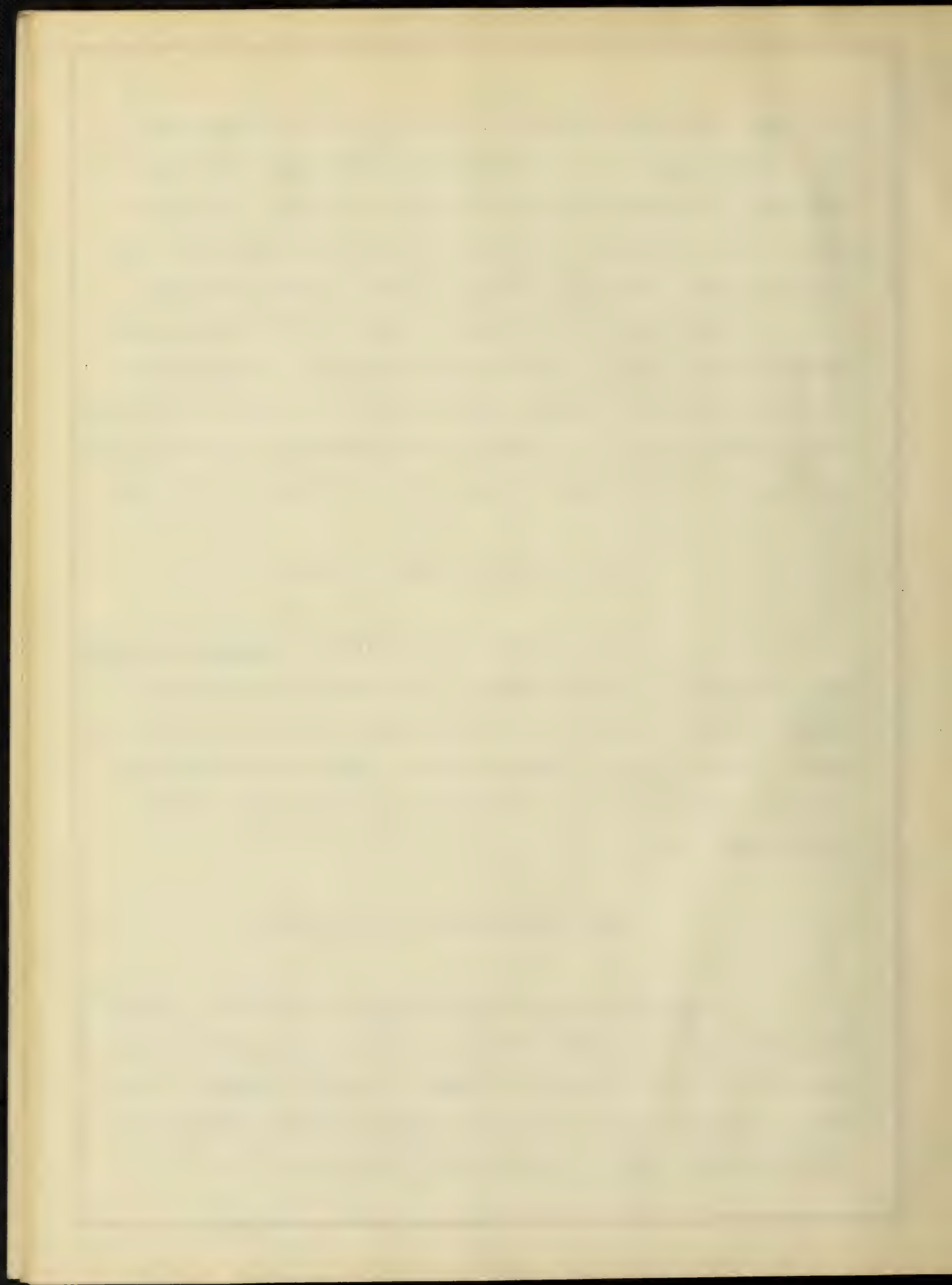
When danger approaches the flight of one grass-hopper seems to warn others. I have counted fifteen to twenty grass-hoppers in retreat. In all cases observed, I am sure the retreating followers were sufficiently far away that they did not detect my approach. They always follow in the direction of the first.

4. Temporary Marsh Association.

In the temporary marsh were found many Petrix granulata. They inhabit the ground stratum. They are poor fliers usually escaping their pursuers by a hop combined with flight. They hop only a short distance, perhaps a foot. Their close resemblance to the ground and by crawling under the debris, they are not easily observed.

III. OBSERVATIONS IN ENVIRONMENT.

Grasshoppers have their enemies and diseases. During the early part of my observations, I found several grasshoppers affected with fungus disease. They had usually crawled to the tops of plants taking a firm grasp and were found hanging where they had died. Many of the specimens kept in the cage in the

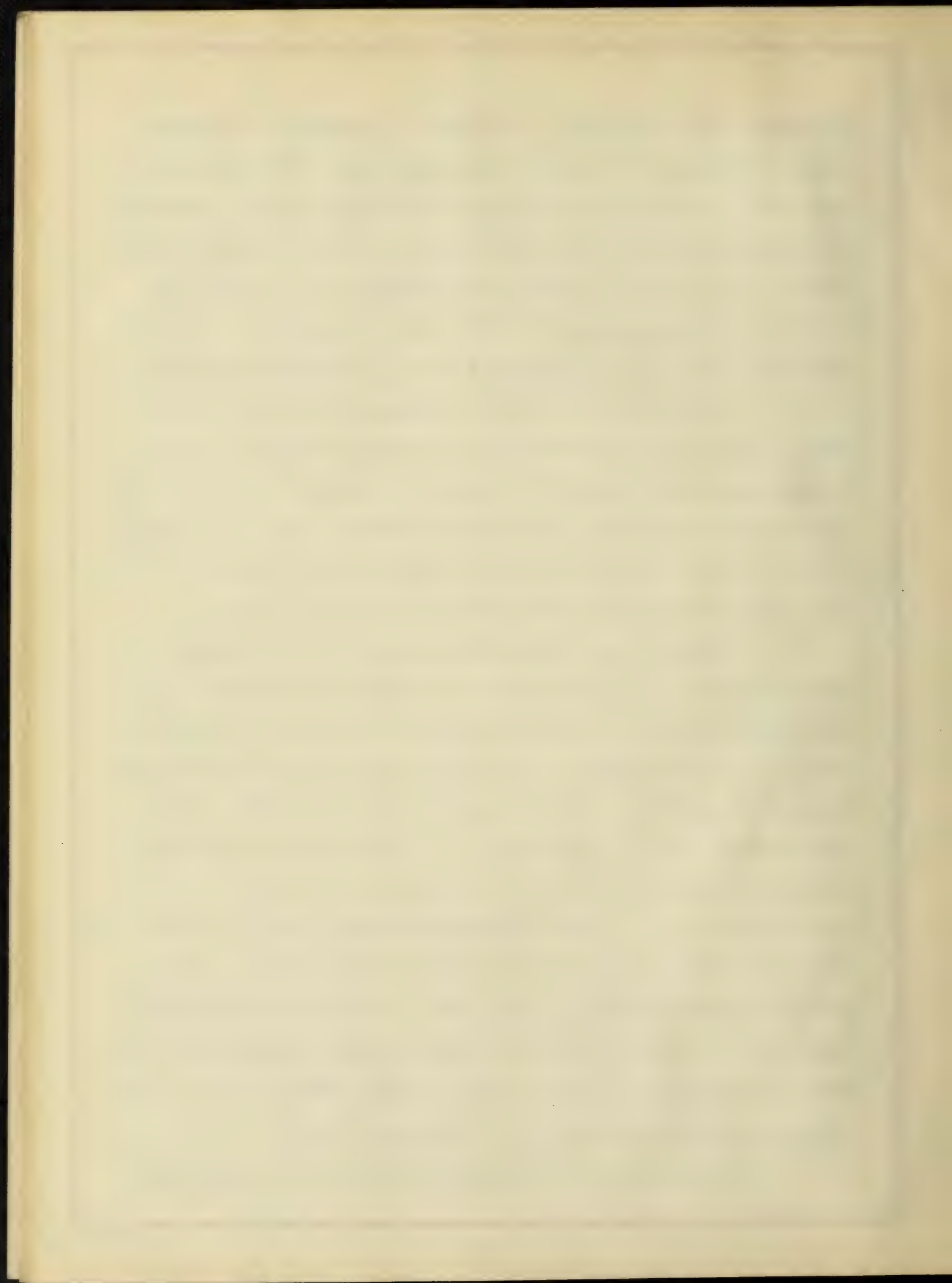


laboratory died similarly. Sometimes a grasshopper in random flight will become entangled in a spider web. I noticed many cases where spiders seemed to lay in waiting in their beautifully constructed webs, for such accidental happenings to take place, rushing out on the trespasser and proceeding to entangle him further. M. femur rubrum meet this death frequently. I have also found large M. difforientalis and M. bivittatus entangled.

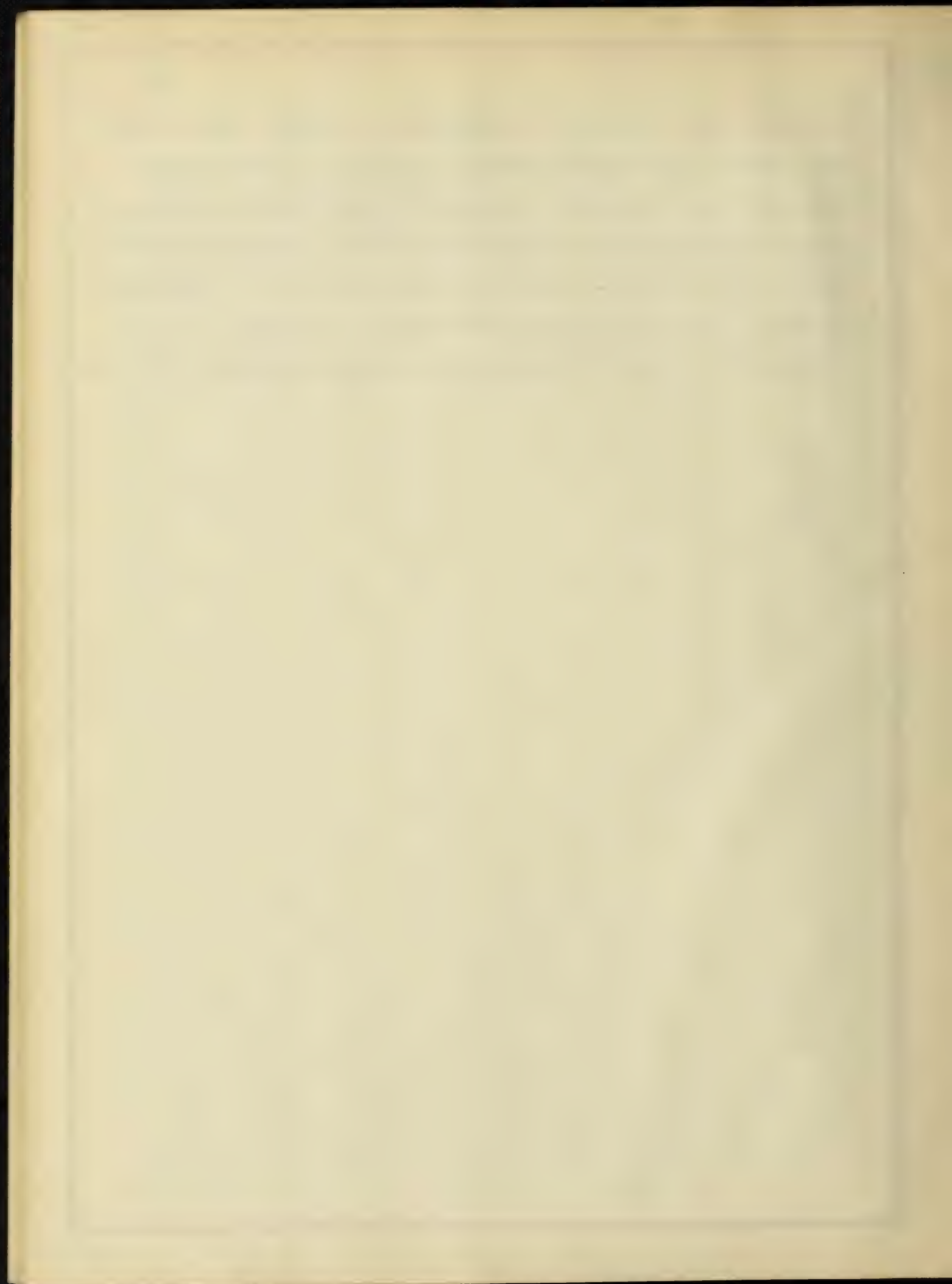
I found wasps capturing nymphs, and carrying them away. Locusts are also victims of Diptera parasites. While keeping some live specimens in vials for identification two large Dipterus larvae crawled out of the posterior end of a M. difforientalis. The locust seemed very sluggish when I placed it in the vial and died soon after the larvae had left the body.

Moulting is an interesting process and very easily observed both in the field and in the laboratory cages. It is a much easier and a more rapid process in the large sized nymphs than in the small nymphs. One small nymph became very sluggish during an experiment. As its actions were not normal, it was removed from the experiment pan. It soon began moulting which process was long and tedious. It worked and struggled for one and one-half hours. Later observation showed that it had not been able to extricate itself but had died in the process. Large nymphs observed moulting in the field attach the claws of the third pair of legs to a twig and hanging head downward, the process soon begins and is completed in about twenty minutes. The observed extremes were eight and thirty-two minutes.

The observation that certain species of insects re



commonly found in the same associations as certain plants, does not justify the conclusion that the insects are there because they feed upon the plants. Looking into the habitat, we find nymphs and adults choosing different strata, different positions, different food plants. Such observations have led to experimental work in order to interpret the relation of animals in their normal environments in terms of their physiological constitutions.



IV. EXPERIMENTAL RESULTS.

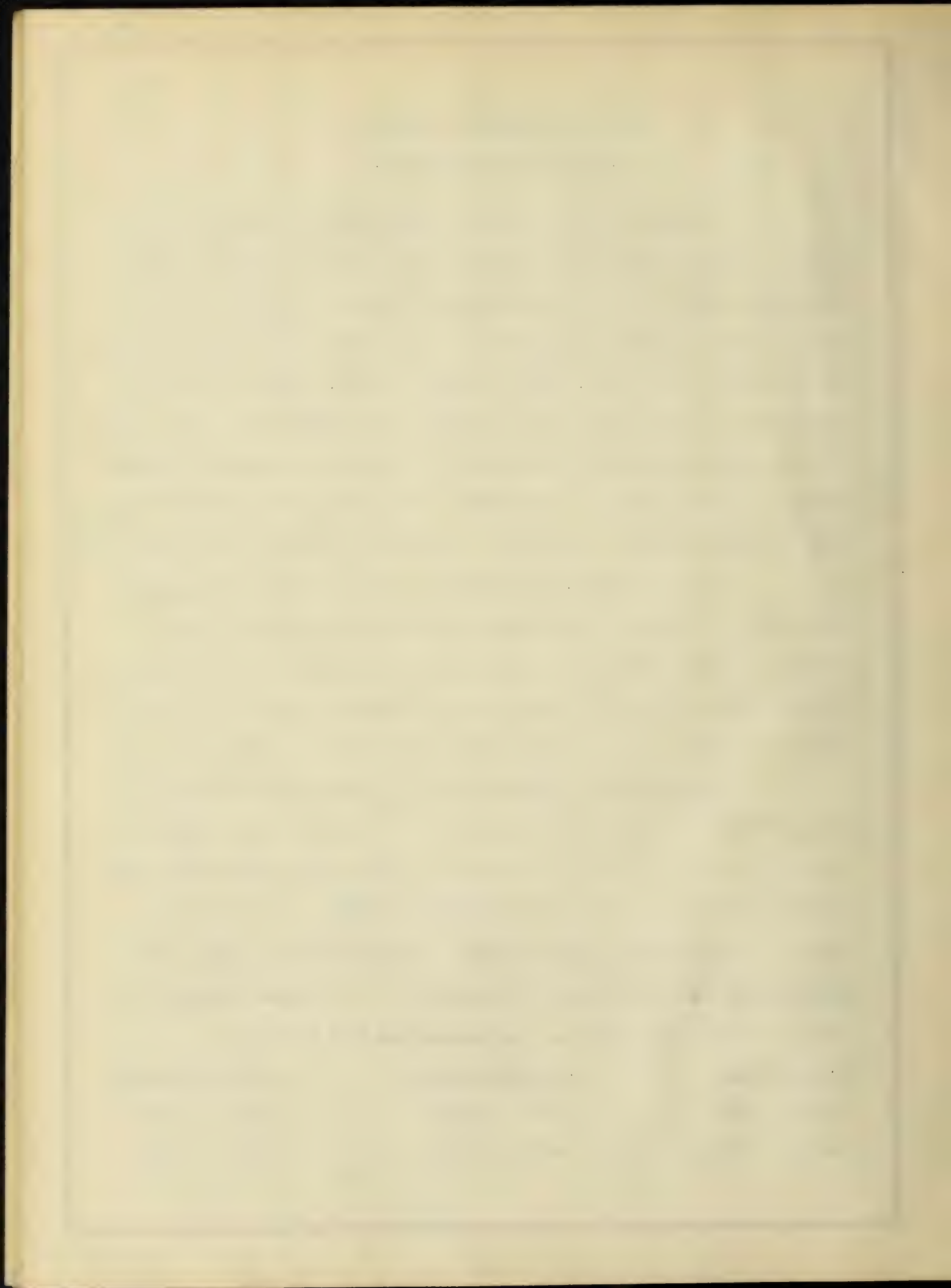
1. Reactions to Light.

A great number of experiments were carried on in the field and laboratory in studying light and its effects. The apparatus used has been described by Shalferd ('17). It consists of pans 12x20 centimeters at the bottom with slightly larger tops and about 7 cm. deep, painted black. Glass tubes with hemispherical ends and caps were used as containers. One third of the inside circumference which is placed downward is painted black. A cover with an adjustable slit was used to allow bright light, medium light, and shade divisions to strike the container.

In the experiments usually five or ten grasshoppers were used. Readings were recorded every five minutes until twenty had been taken. In cases where data did not seem conclusive five experiments were run and averages made. In other cases only the most representative data will be given.

Experiments in phototaxis show that grasshoppers do not all exhibit the same responses. One species may respond in one way, another in another manner. Juveniles may react very differently than the adults of the same species. In tests with adults of Melanoplus femur rubrum, Dioscorella carolina, and Melanoplus differentialis, D. carolina and M. femur rubrum were positive to light while M. differentialis was negative.

<u>D. carolina</u>		<u>M. femur rubrum</u>		<u>M. differentialis</u>	
Light	Dark	Light	Dark	Light	Dark
89%	71%	86%	74%	89%	86%



It is noticeable that the nymphs of A. fennii rubrum and D. carolina do not respond to light as do the adults, but in both species the adults are found to be positive and the nymphs negative.

Adult A. fennii rubrum

Light	Dark
66%	34%

Nymphs of A. fennii rubrum

Light	Dark
33%	67%

Adult D. carolina

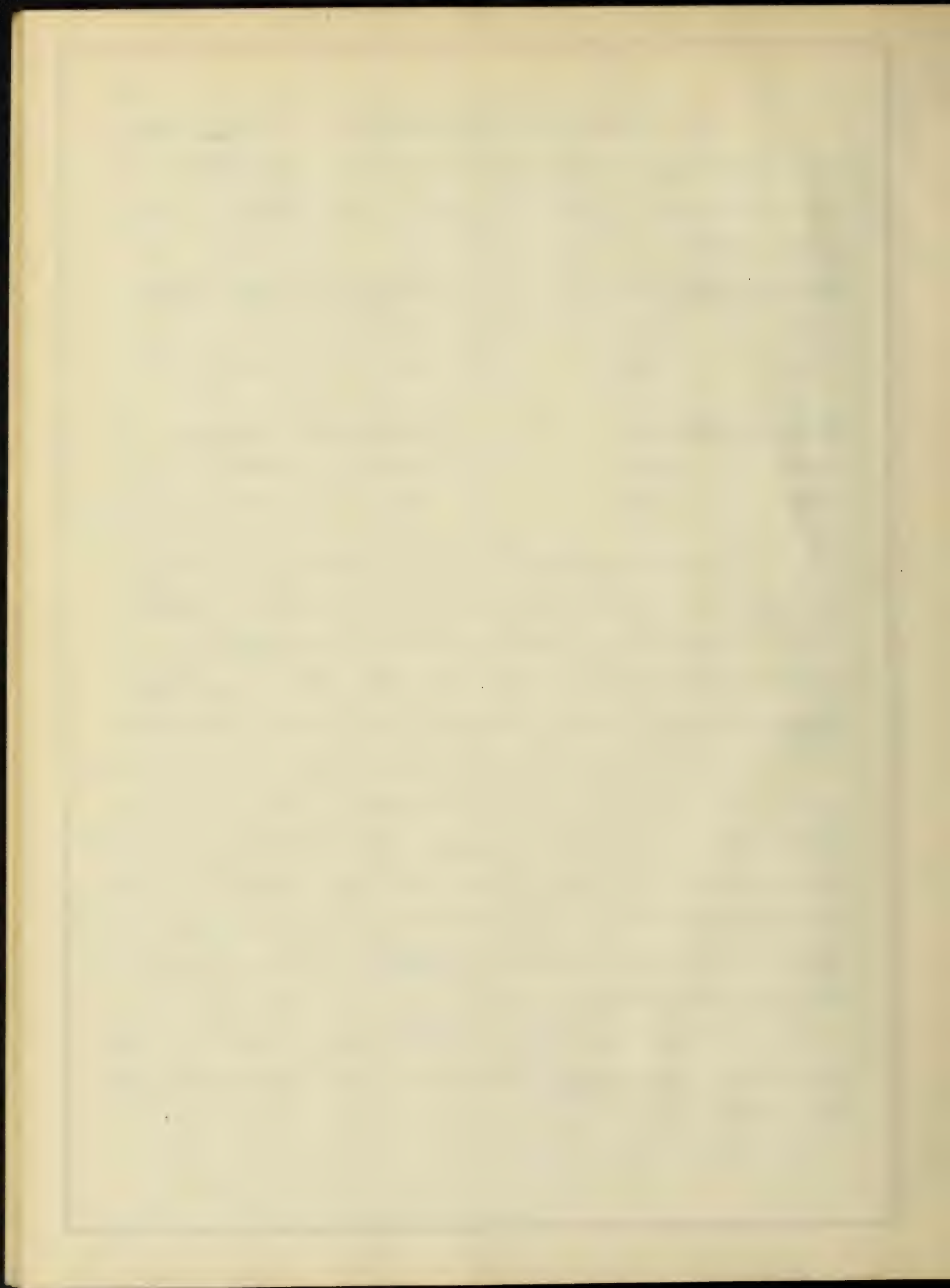
Light	Dark
72%	28%

Nymphs of D. carolina

Light	Dark
40%	60%

It is significant that the difference in reaction between the nymphs and adults of these two species corresponds with the difference in light conditions in the localities in which the two stages are found. Thus the adults of A. fennii rubrum were usually exposed to light on the tops of the stalks of sweet clover, while the nymphs were hidden on the under sides of the leaves of plants of the low growth or among the grasses. Similarly the adults of D. carolina were found on the bare clay banks exposed to the direct rays of the sun, while the nymphs were invariably found in the partially protected situations formed by grasses, growth of clovers, perennials, and similar vegetation near the foot of the clay bank.

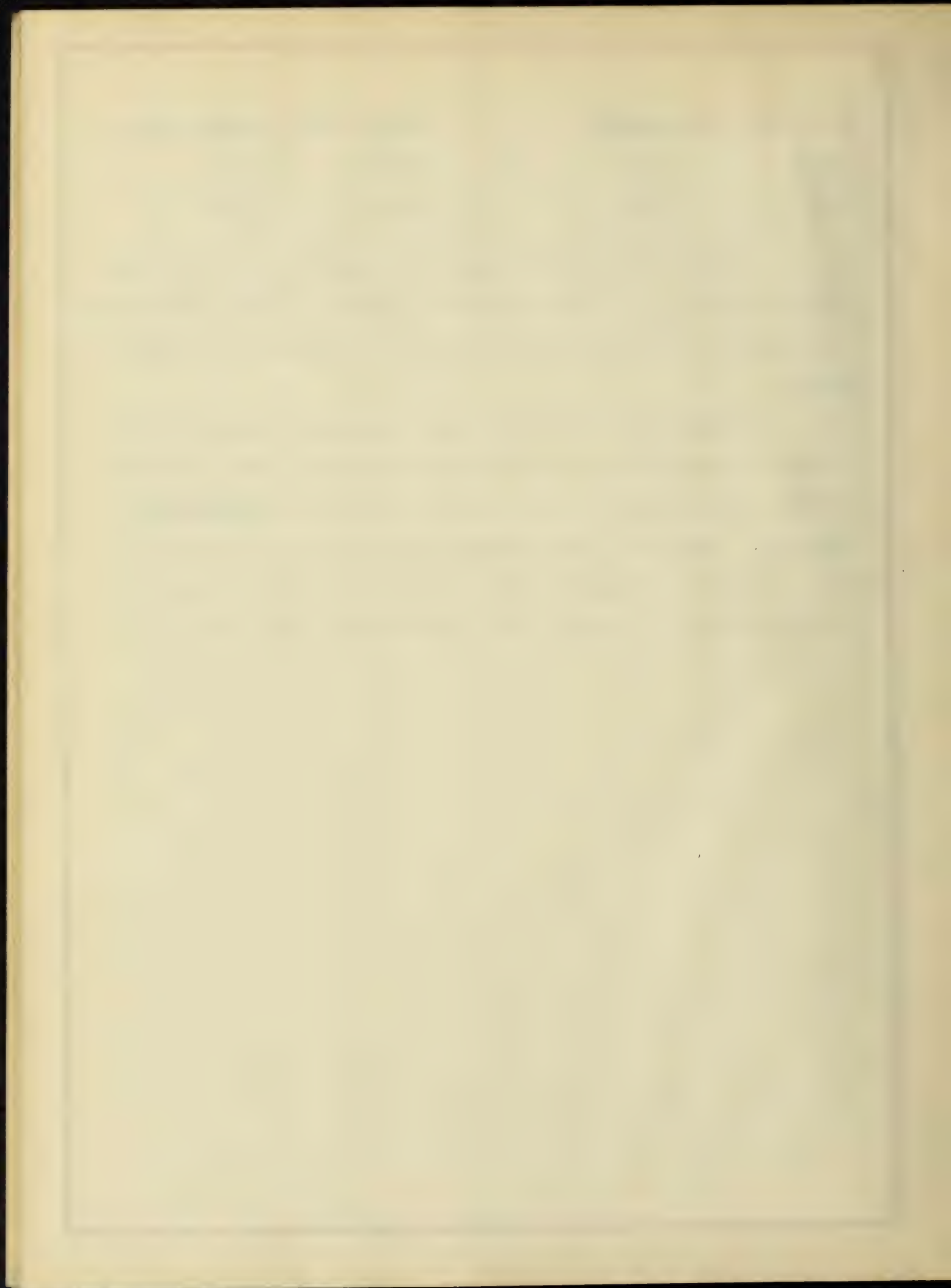
In contrast to the above two species, the nymphs and adults of A. fennii rubrum and D. carolina are alike in their reaction to light, both being positive.



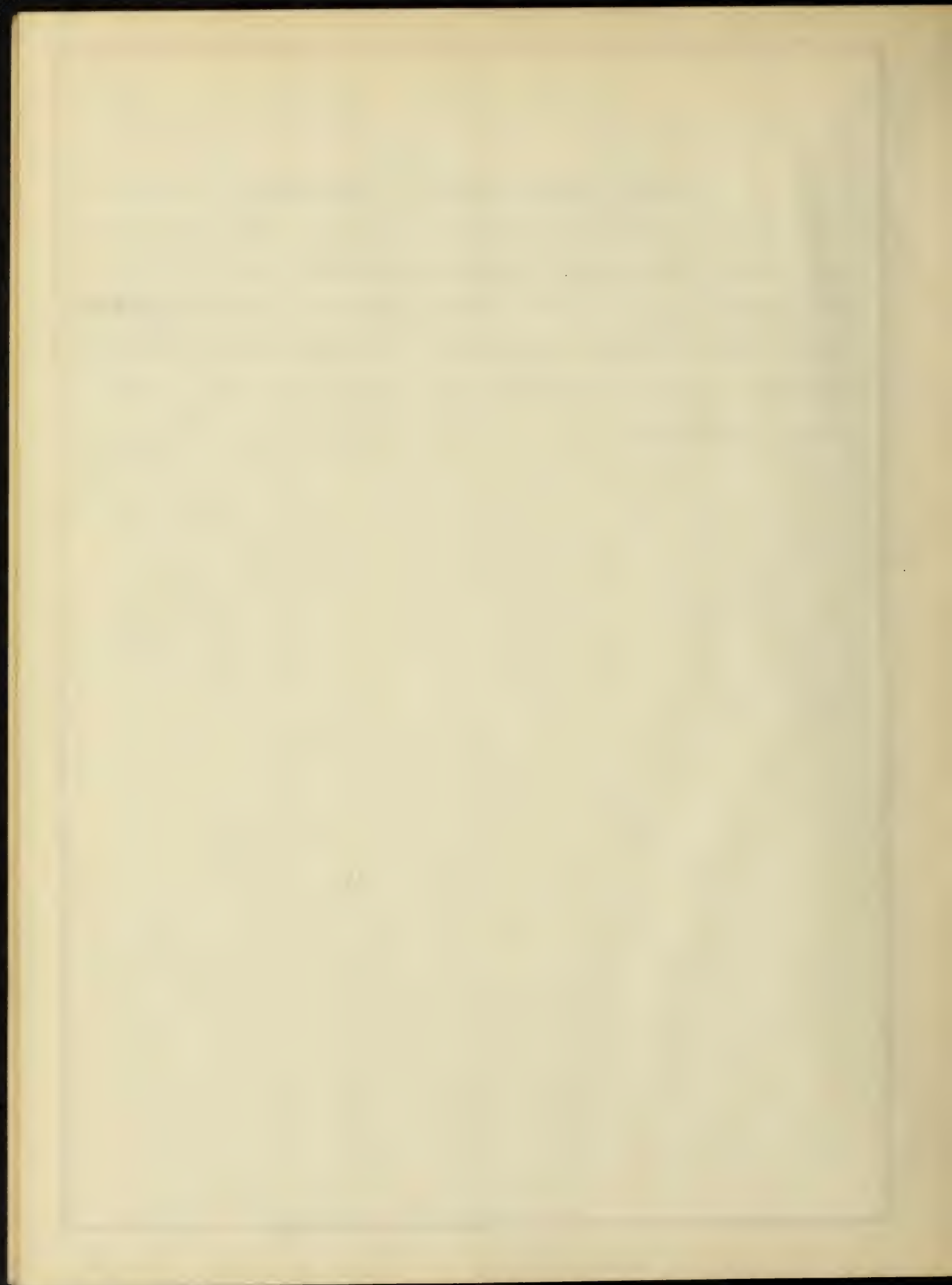
Adult <u>L. differentialis</u>		Nymphs of <u>L. differentialis</u>	
Light	Dark	Light	Dark
10%	50%	30%	70%

Here again the responses under experimental conditions are what would be expected from the character of their habitat for both nymphs and adults are confined to conditions of moisture and shade.

Experiments in direct light when heat becomes a factor as was the case of some experiments run at noon, show a negative reaction toward light in all species tested except Disceptaria carolina. When heat became intense the adults of this species died. None of the nymphs died. (This would indicate that the nymphs were able to stand greater temperatures than the adults.



(a) Intensity and Direction.-- Experimented in intensity and direction were performed in the dark room in the direction with the yellow light grater, (described by Shalvard '11). It was found that in some cases the animals had habits of a species react alike, while in others the reactions were reversed. The number of reactions and the reaction taken were the same as in former light experiments.

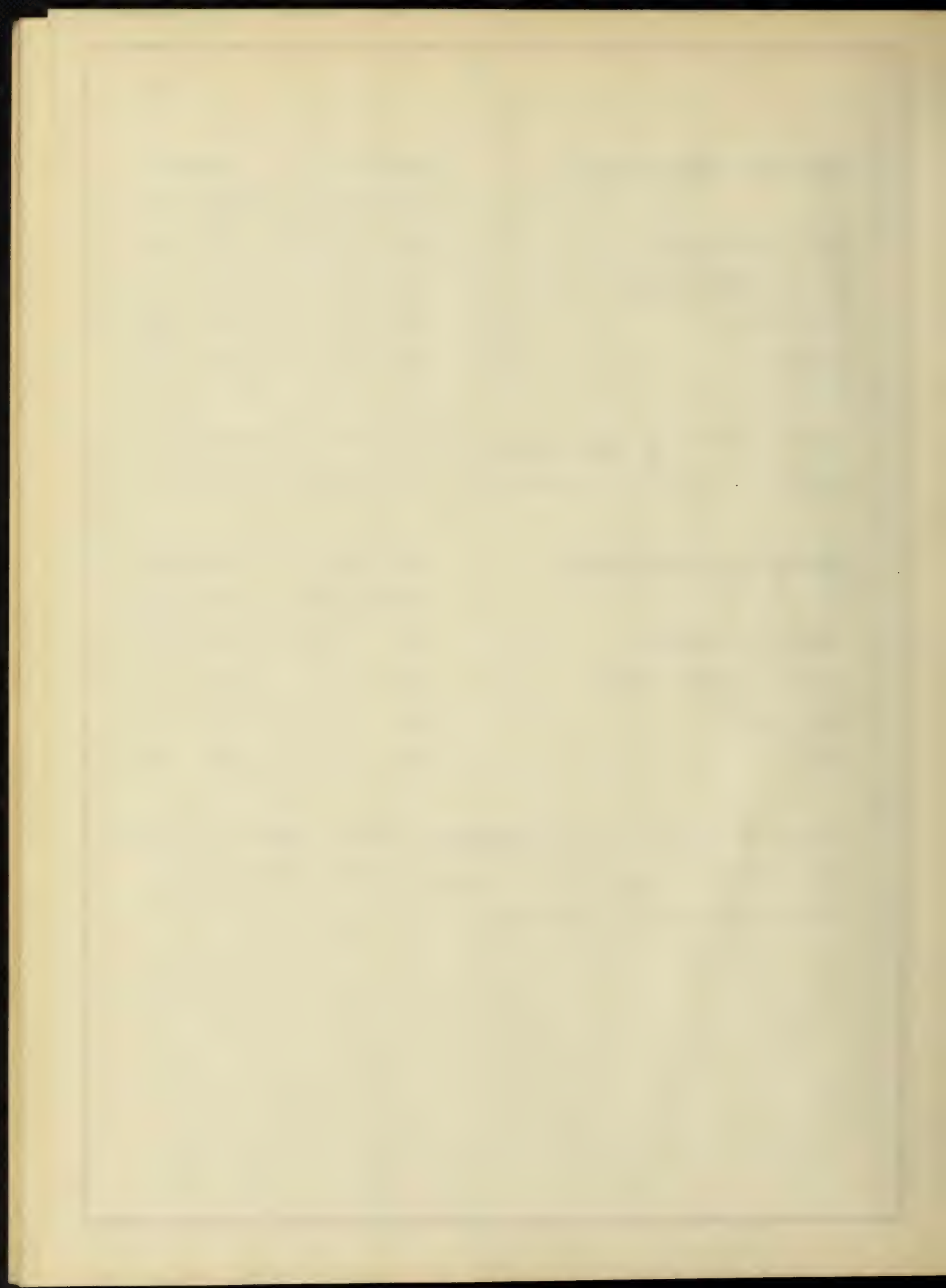


<u>Relationships toward symbols</u>	Direction		Intensity	
	Light	Dark	Light	Dark
Very small symbols	40	40	41	50
Second & third stage	51	53	40	50
Last stage	70	55	71	51
Adults	84	55	85	50

Small symbols of M. linear symbol are negative to direction and intensity. Adults are positive to direction and intensity.

<u>Relationships Differentiation</u>	Direction		Intensity	
	Light	Dark	Light	Dark
Very small symbols	44	50	54	70
Second & third stage	58	52	50	70
Last stage	54	60	49	50
Adult	52	68	48	50

Symbols and Adults of M. Differentiation are negative to direction and intensity. Adults are less negative to direction, symbols are less negative to intensity.



<u>Diastocira carolina</u>	Direction		Intensity	
	Light	Dark	Light	Dark
Nymphs	98%	10%	76%	34%
Adults	66%	33%	66%	34%

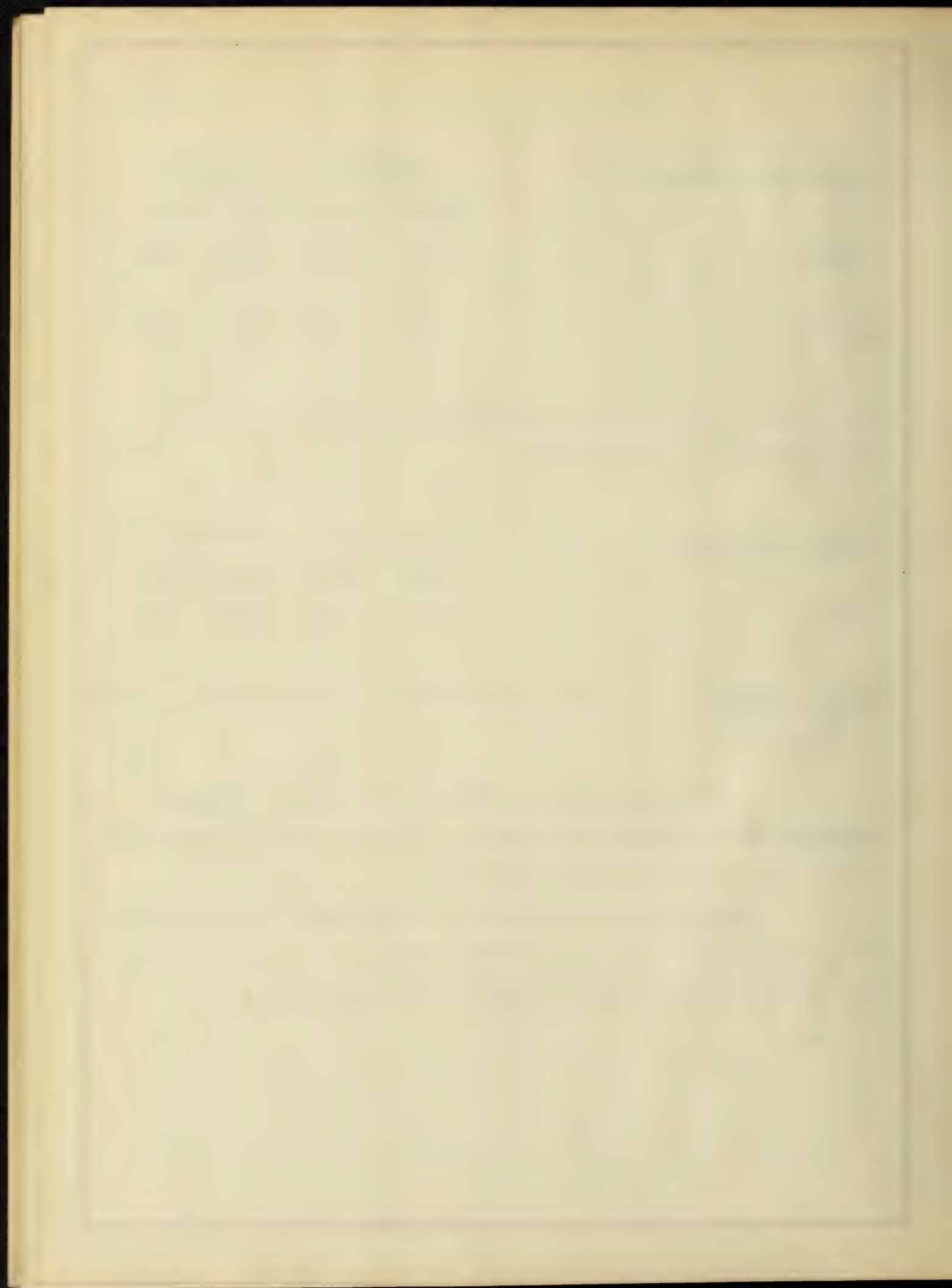
Both nymphs and adults of D. carolina are strongly positive to both intensity and direction.

<u>Tetrix granulata</u>	Direction		Intensity	
	Light	Dark	Light	Dark
Adults	51%	49%	55% - 75%	

Tetrix granulata is somewhat indifferent to direction but negative to intensity.

No experiments were performed with nymphs of Tetrix granulata because the early stages of this form were not available at the time this work was in progress.

Here, again as in case of the experiments on phototaxis, we find an exact correlation between the reaction of the insects and the conditions in the habitat in which they occur.

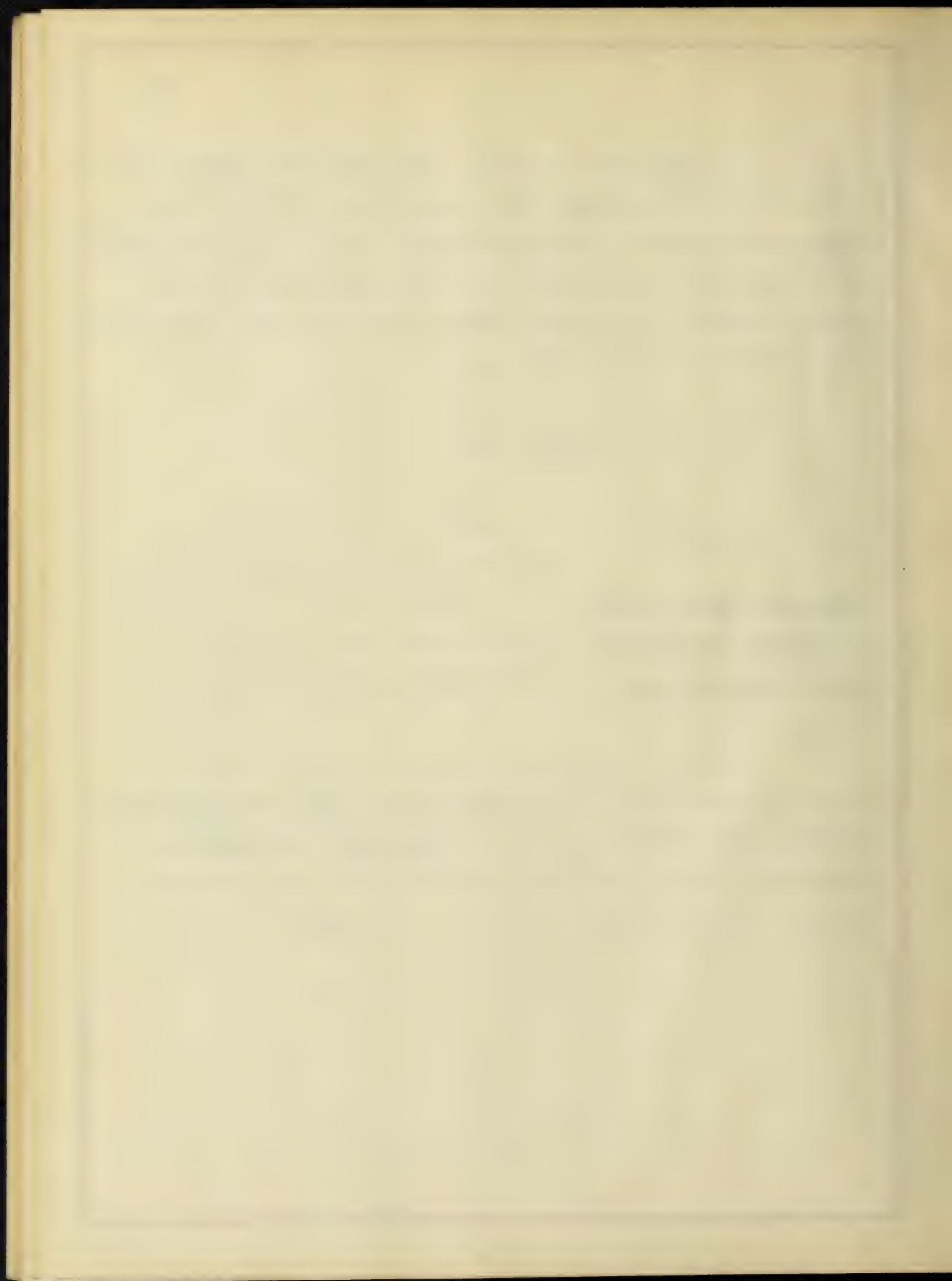


(13) Reactions to Colors.-- An attempt was made to find out reactions of grasshoppers to the different colors of the spectrum in order of phototrophic power. A cover for the container was made from colored gelatine sheets and arranged in the order,-- violet, blue, green, yellow, orange, and red. The light was furnished by a forty watt lamp.

COLOR TESTS.

	Adults						Nymphs					
	V.	B.	G.	Y.	O.	R.	V.	B.	G.	Y.	O.	R.
<u>Melanoplus femur rubrum</u>	0	7	20	46	2	17	5	7	33	24	16	19
<u>Melanoplus differentialis</u>	13	12	17	19	13	18	1	10	19	12	33	25
<u>Dissosteira carolina</u>	12	10	33	26	15	9	17	12	59	12	14	8

There is a general preference for green and yellow in both nymphs and adults of Melanoplus femur rubrum and Dissosteira carolina. The nymphs and adults of Melanoplus differentialis prefer orange and red. This is in agreement with other light reactions in which insects prefer shade or darkness.

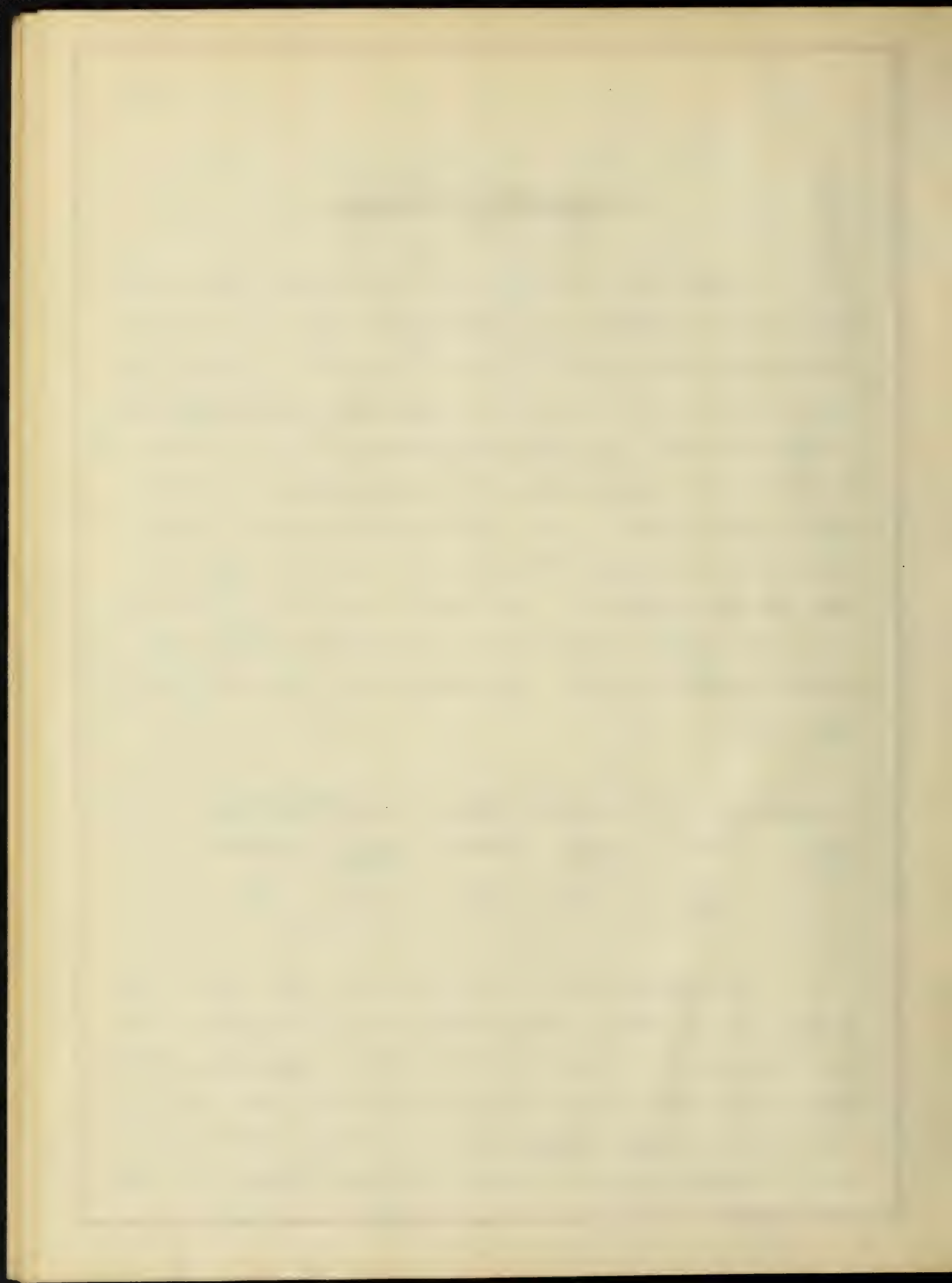


2. Reactions to Surface

Field observations show that grasshoppers vary in the kinds of resting places which they choose. There is a distinct difference in the species as well as a difference in adults and nymphs of a species. For example, Dissosteira carolina clights on the bare ground, Melanoplus differentialis usually on stems. The nymphs of M. differentialis or M. femur rubrum are usually found on leaf surfaces, while the adults prefer stems. Experiments testing this point were carried on using the apparatus described by Shelford '17. As stimuli I used square sticks of mint, round stems of plants, strips of corrugated paper, mica, pebbles, quartz, and sand. The readings were taken as in the light tests.

<u>D. carolina</u>		<u>M. femur rubrum</u>		<u>M. differentialis</u>	
Smooth surface	Sticks	Smooth surface	Sticks	Smooth surface	Sticks
76%	22%	44%	56%	33%	66%

D. carolina showed no preference for the sticks. They crawled over the sticks, always taking the smooth surface of the grass in preference to crawling on the sticks. Femur rubrum always followed the sticks after coming in contact with them. In very few cases did M. femur rubrum walk on the smooth surface of the grass. M. differentialis also showed a decided preference for the



sticks. In experiments in which I used large, small, and square sticks, M. differentialis seemed very active when on sticks of small circumference, but became very quiet when on sticks of larger circumference.

In experiments with nymphs and adults of M. fuscus rubrum in which mica was used as a stimulus, I found that the adults showed a preference for the bits of mica. They would crawl from the bits of mica to the smooth surface, immediately turn around and become quiet on the rough surfaces of the mica. The nymphs seemed to show little preference for the mica.

Adults M. fuscus rubrum

Mica smooth surface

75%

54%

Nymphs M. fuscus rubrum

Mica smooth surface

36%

44%

I next tested nymphs and adults with sticks of circular, oval, square, and triangular sticks of wood.

Adults M. fuscus rubrum

Sticks smooth surface

64%

55%

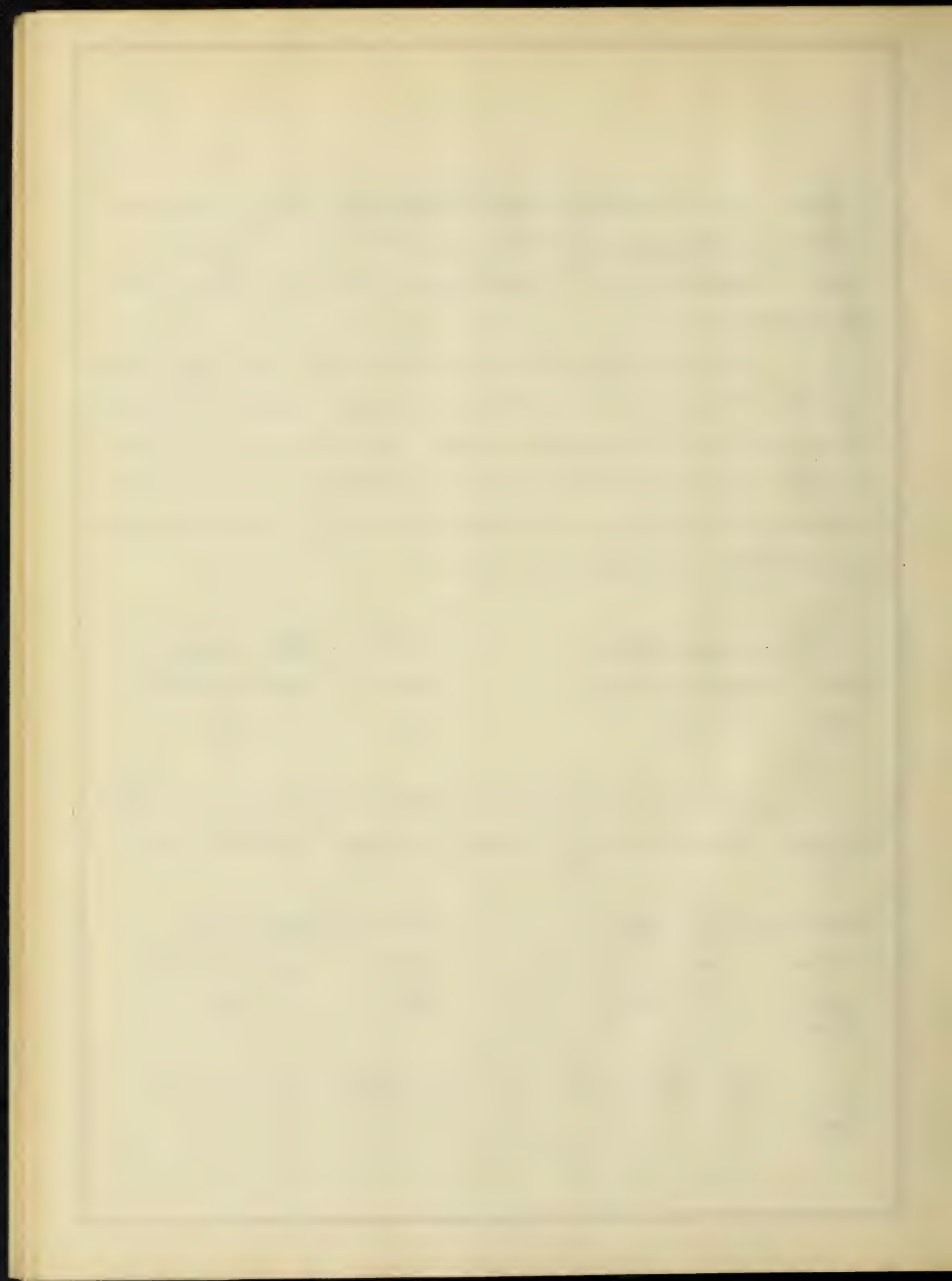
Nymphs M. fuscus rubrum

Sticks smooth surface

55%

45%

The adults preferred round surfaces, the nymphs the flat.



5. Reactions to Temperature.

Temperature plays an important part in the life of a grasshopper--some seeking cool shaded habitats, others dry warm places.

In the experiments gradients were established and maintained by placing two pans on the water table and allowing hot water to flow into one, cold into the other. A third pan was set across these two so as to allow the water to come in contact with the cold at one end and the warm at the other, (Shelford '17). Sand and black dirt were used as a floor in the pan. Temperatures of 50° C. (hot) and 25° C. (cold) were maintained.

Adults M. femur rubrum

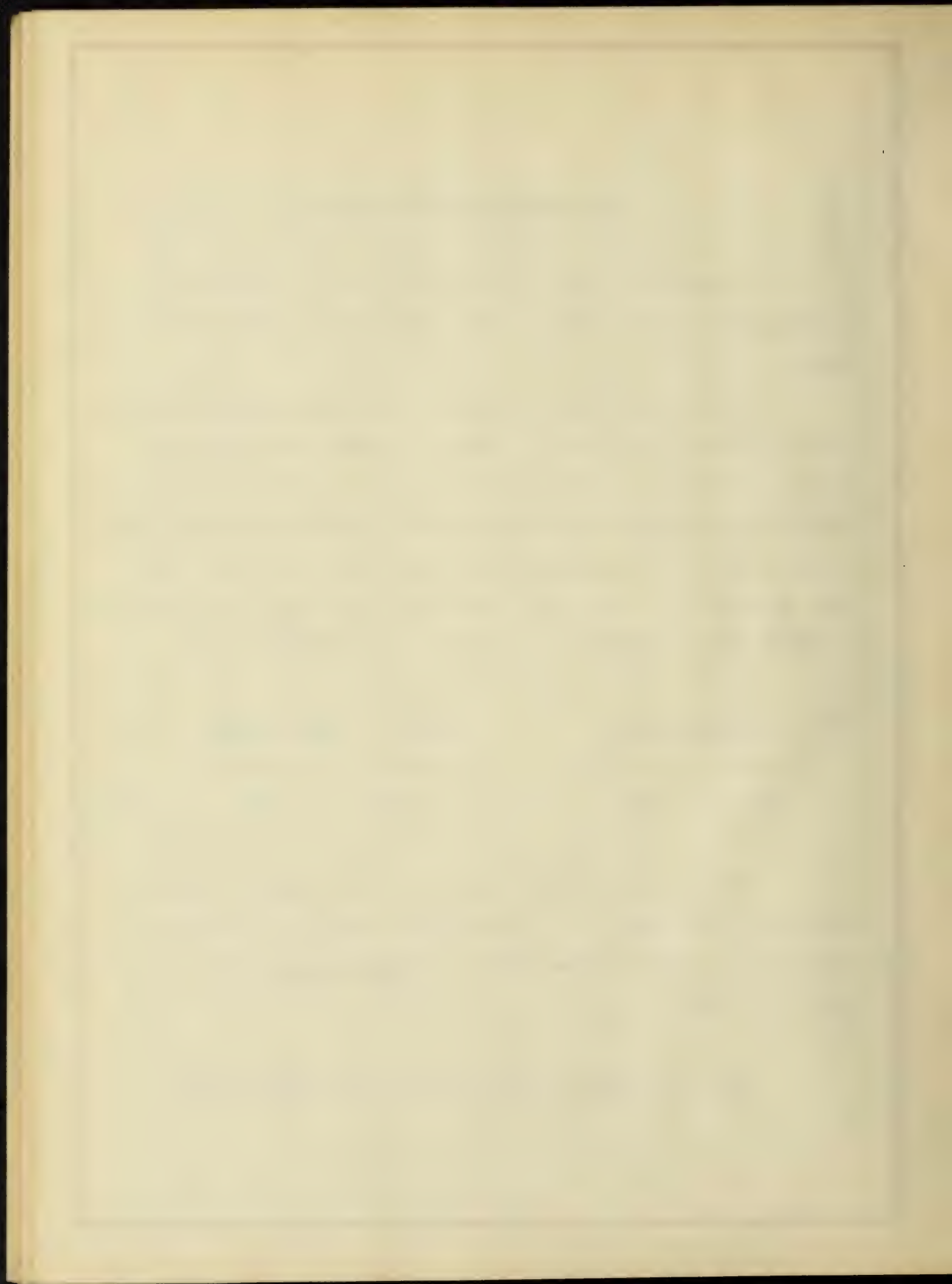
Hot 50°	Cold 25°
57%	55%

Nymphs M. femur rubrum

Hot 50°	Cold 25°
48%	54%

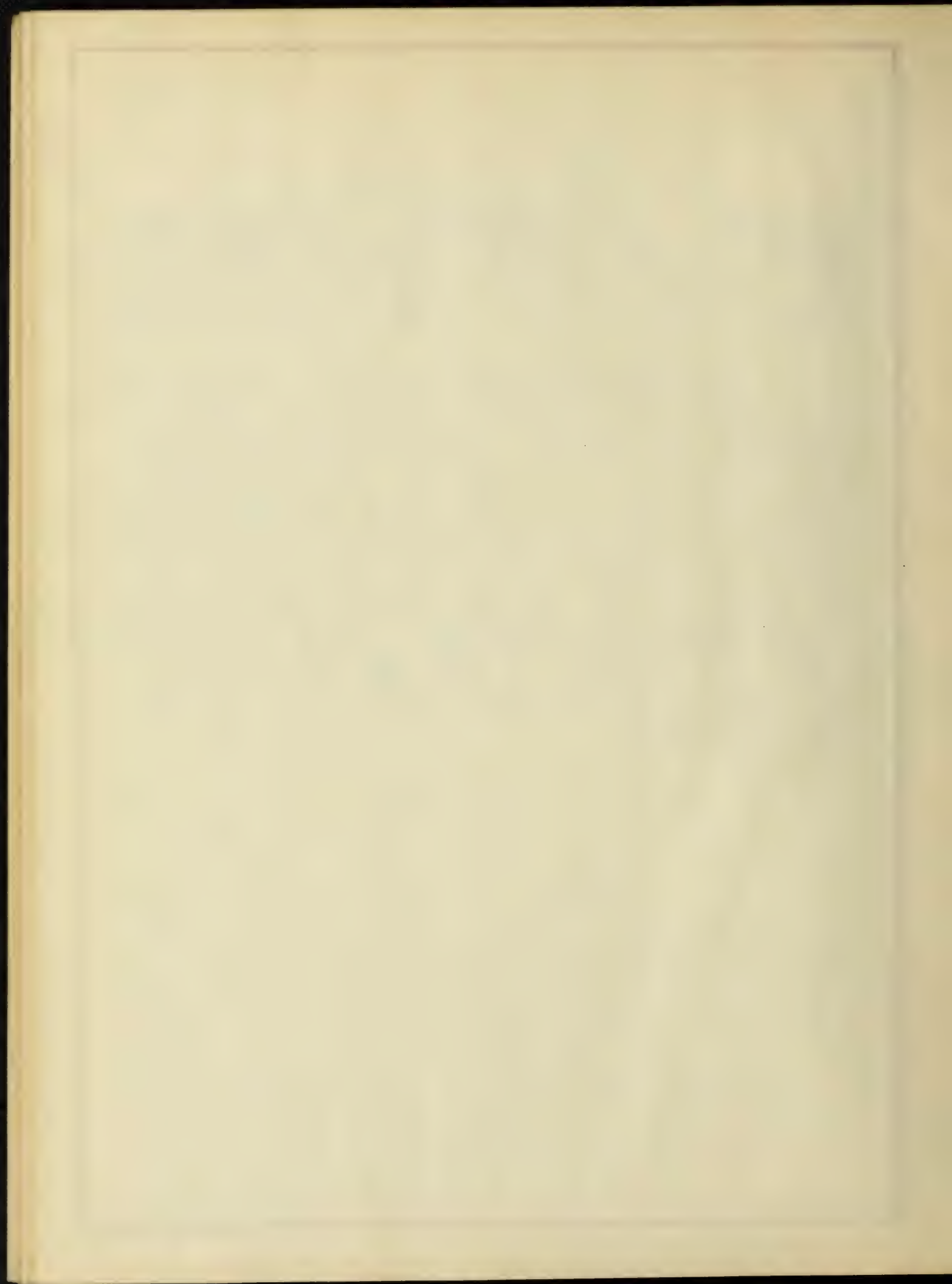
The nymphs were very inactive and usually remained in either temperature. All experiments showed a slight preference for cool temperatures. Nymphs of A. trivittatus were not negative to heat.

I have subjected adults to the same temperatures.



<u>D. carolina</u>	<u>M. formicivora</u>	<u>M. differentialis</u>			
Not 10°C. cold 15°C. Not 20°C. cold 25°C. Not 30°C. cold 35°C.					
84%	11%	30%	40%	54%	75%

D. carolina moved out of the cool region in the jar and became inactive in the warm area. M. differentialis was not excited when coming into the warm area. They would either turn directly around moving to the cool area, or jump ahead into the warm area moving about actively, usually finding their way out or jumping to the cool area. M. formicivora were not as active as either D. carolina or M. differentialis. They are slightly positive to heat. Adult specimens of M. formicivora when subjected to high temperatures did not before the species used showed any signs of agitation.

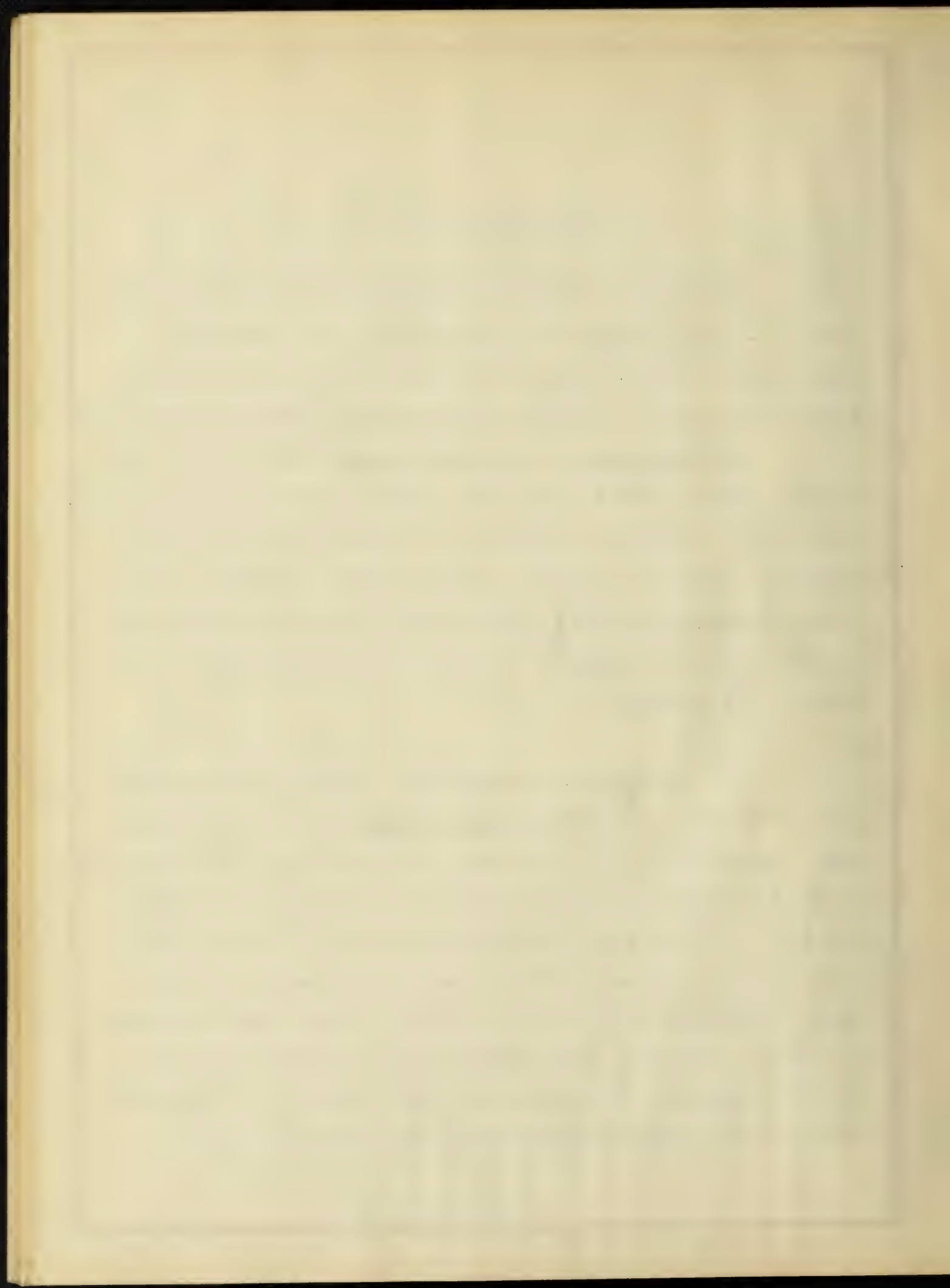


4. Reactions to Gravity.

Experiments in posture did not show very decided results. M. femur rubrum and M. differentialis are undoubtedly negatively geotactic. Phototactic stimuli seem to be greater in effect, unconsciously altering the grasshopper's response to gravity.

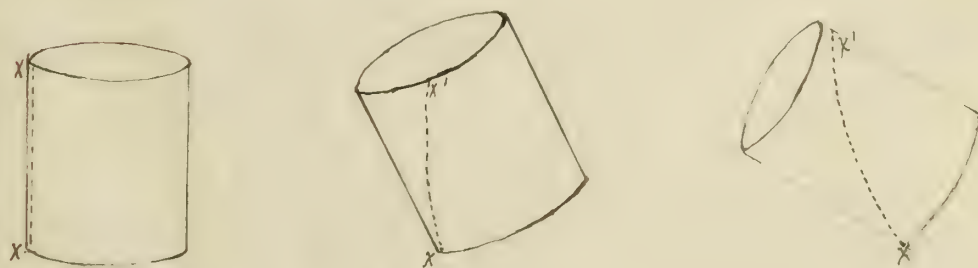
M. femur rubrum and M. differentialis crawl up the sides and upon reaching the top they jump usually alighting on the ground sometimes on a stick that is nearer the surface than the former position. They then proceed to crawl up again. Little is known I think D. carolinensis indicate a decided positive geotactic response. This species which in nature is found on the ground remain on the floor of the container.

(A) Orientation.-- Grasshoppers usually orient head upward to the sky. I placed M. femur rubrum in a cylindrical wire cage. During the cage is the side, the grasshopper took a position on the end of the cylinder with the head upward. As the cage rotated, the grasshopper moved, always walking in a circle and always keeping the head upward. When the cage was moved faster than the grasshopper's rate of movement, it would jump to another position in the cage. The test was made on several specimens, all of which responded in the same way, always moving in a circle and moving in the direction that the cage was rotated.



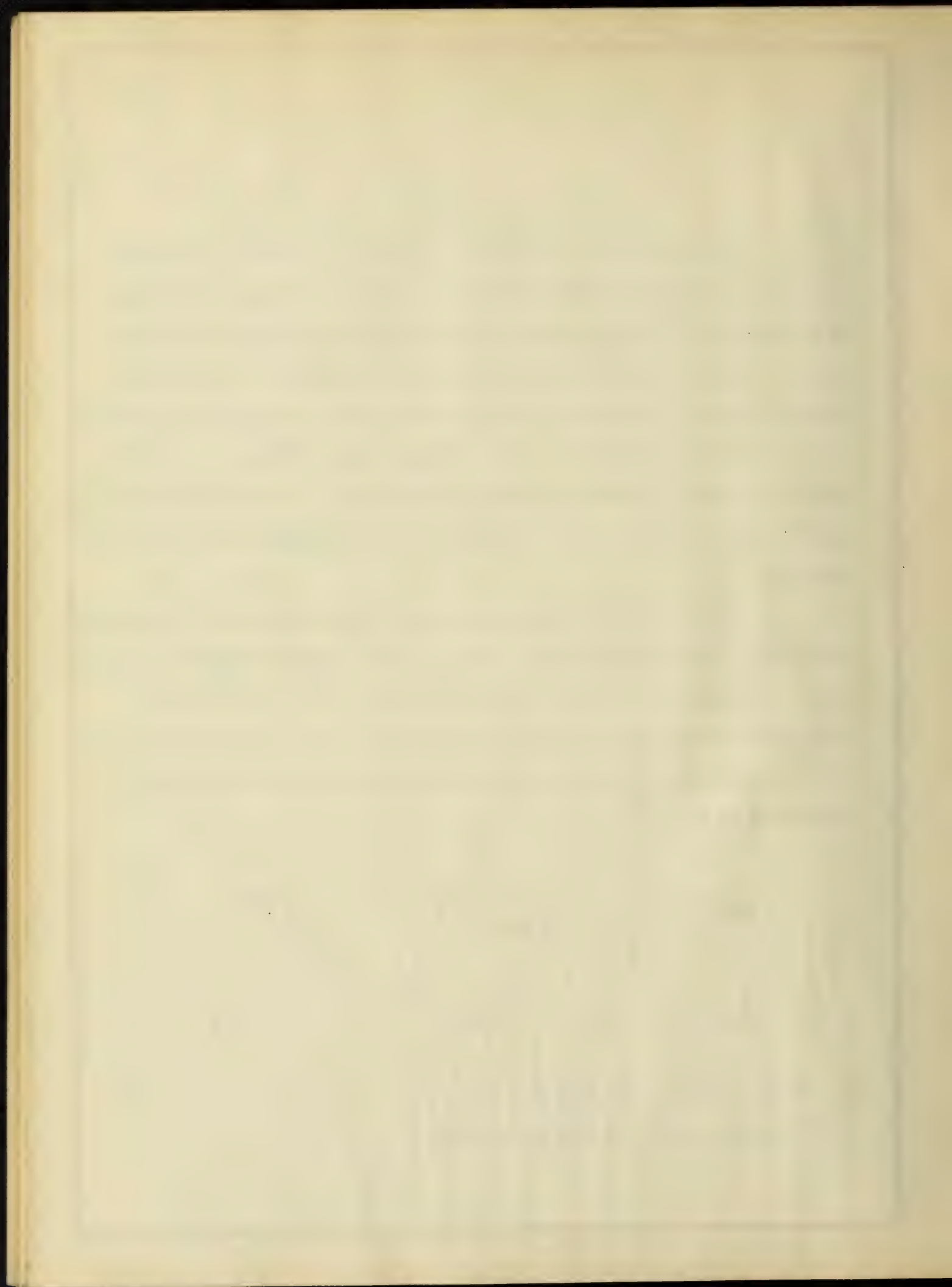
I next placed the cage on the side rotating it slowly. This time the grasshopper was on the side of the cage. I turned the cage about fifteen degrees so that the grasshopper would be on the side of the cage but with the head downward. At once it walked forward. Rotating the cage I was able to keep it relatively in the same position. After a time, being unable to walk to a position where it would be normally oriented, it jumped taking a position head upward. This experiment was repeated with the same results.

I next placed the grasshopper on the bottom of the cage, this time slanting the cage at an angle of fifteen degrees. It traveled upward in a spiral path arriving at the top at about fifteen degrees from the former position. If the cage was slanted at a greater angle the path traveled became greater forming a greater angle.



X - first position of the grasshopper.

X' - position taken by the grasshopper.

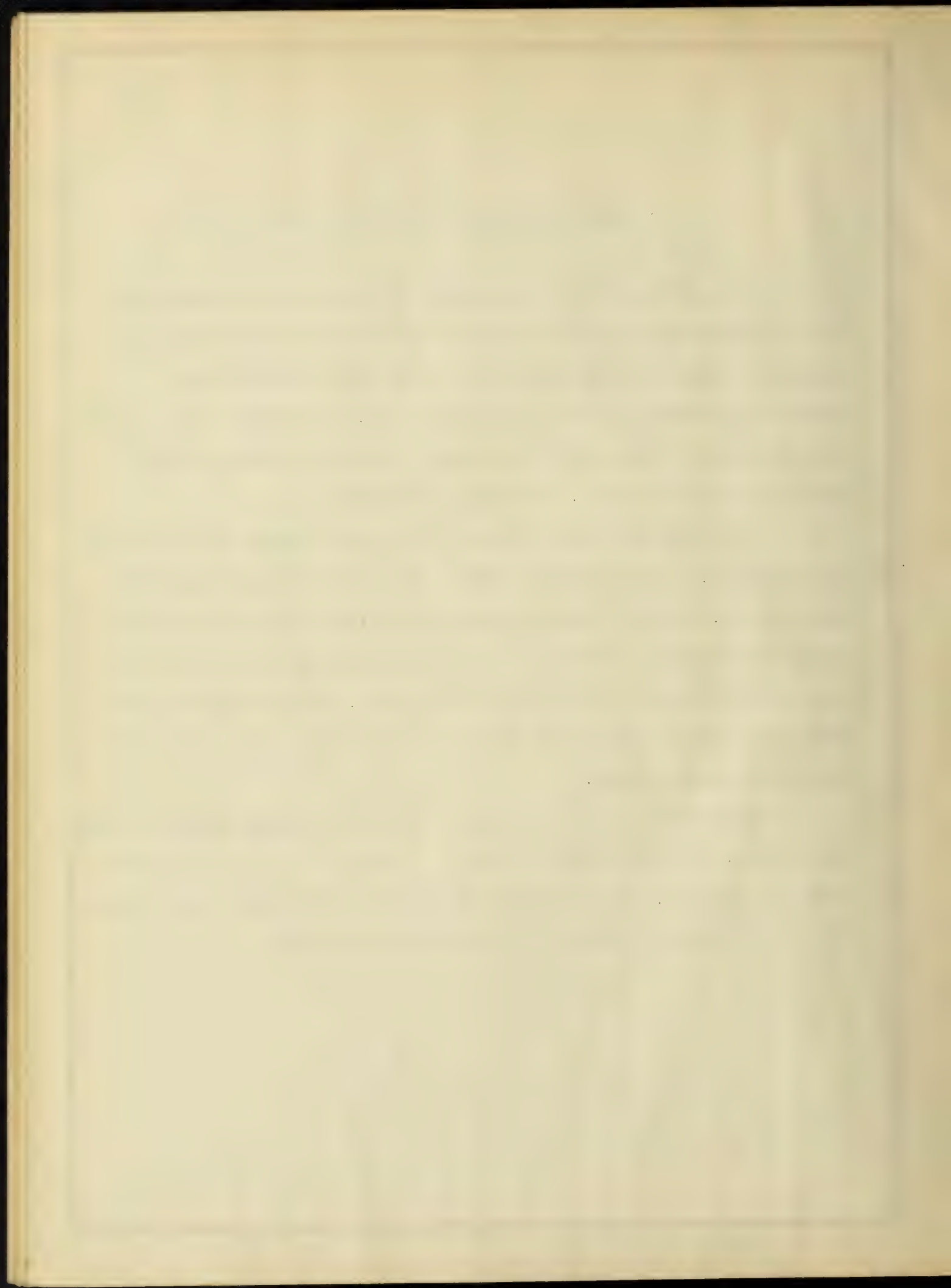


3. Experiments in Evaporating Power of Air.

Experiments were performed to determine the reactions of the grasshoppers to air of different evaporating powers. The apparatus used was essentially the apparatus described by Shelford and Deere (1912), Hamilton ('17), and Moore ('17). The experiments covered a period of forty minutes, readings being taken every two minutes. Five animals were used.

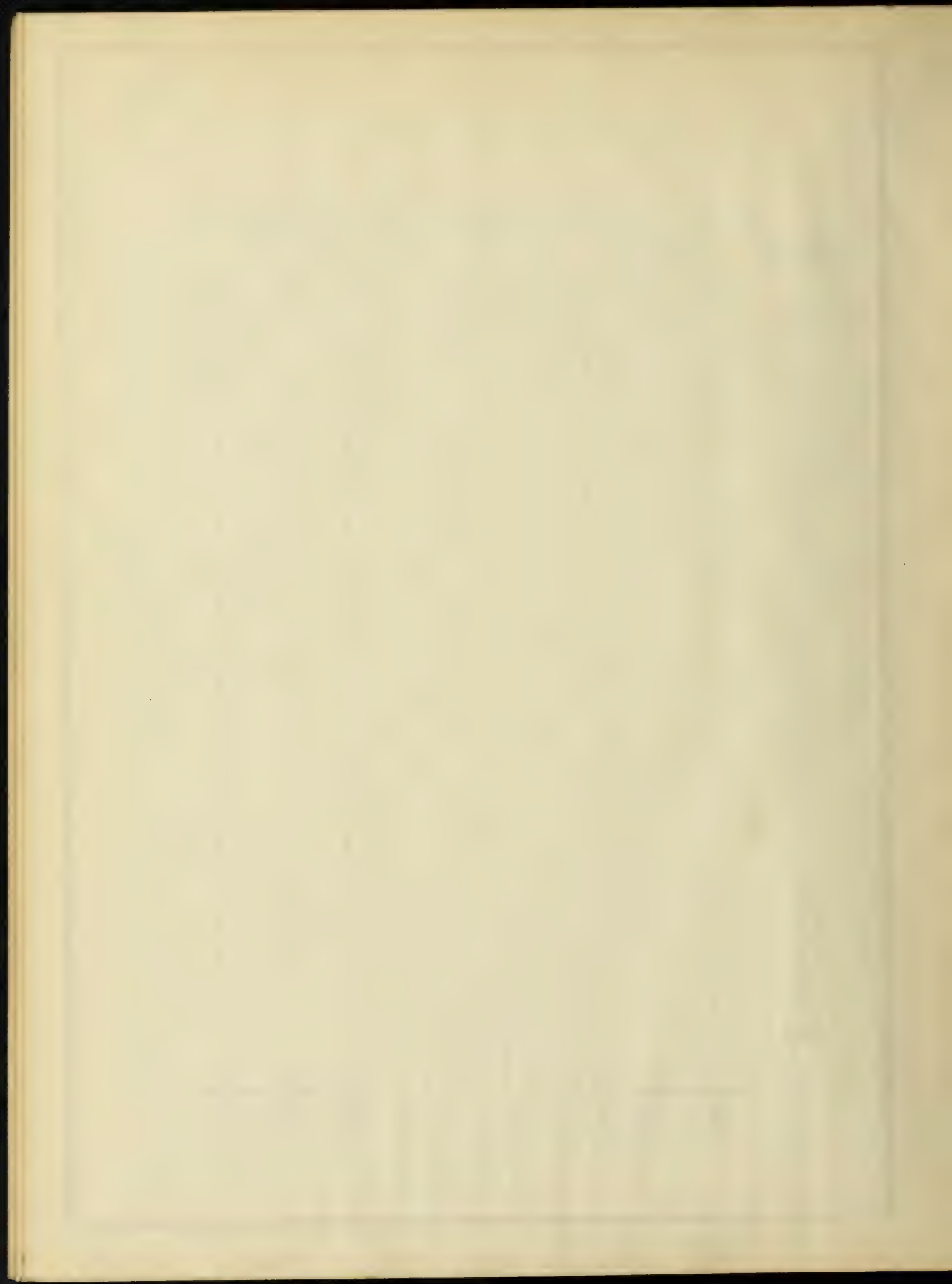
The grasshoppers show a dislike for either moist or dry air currents. When first placed in the gradient cage they are very active. Finally they arrange themselves on the wire screen opposite the entrance of the air currents and become quiet. If they come to rest on the floor of the cage, they orient with the head away from the currents of air. This would show them to be negatively anemotropic.

The data given below was taken on M. femoralis rubra nymphs and adults. In all species there is a tendency to show a preference for dry air, nymphs showing a greater preference than adults. The data given is typical for all species studied.



Asalts.

Minutes	Humidity		
	80	55	25
1	3	1	1
2	1	3	1
4	3	1	1
6	2	1	2
8	2	1	2
10	0	5	0
12	2	2	1
14	3	1	1
16	2	2	1
18	2	2	1
20	1	0	3
22	0	2	3
24	1	2	2
26	1	2	2
28	1	1	3
30	0	1	3
32	0	2	2
34	0	2	2
36	0	2	2
38	0	2	2
40	0	2	2
42	0	2	2
44	0	2	2
46	0	2	2
48	0	2	2
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788	0	2	2



V. CONCLUSIONS.

Grasshoppers tend to form associations. This habit is little affected by choice of food, but rather according to responses to light, surface contact, temperature, gravity, and the evaporative power of air.

Nymphs and adults select somewhat different habitats and show a corresponding difference in their reactions to environmental stimuli. Thus, nymphs choose broad, flat leaf surfaces of the lower strata, adults take positions on the stems.

Four stations were studied: the brick margin, clay bank, sweet clover, and temporary marsh. Each station has its distinctive species. Melanoplus differentialis is found in the brick margin; Dissosteira cincta on the clay bank; Melanoplus femur rubrum in the sweet clover; Tetrix granulata in the temporary marsh.

The following table briefly summarizes the reactions of the grasshoppers to the various factors of their environment. These reactions as has been repeatedly pointed out are correlated with the differences in the habitats chosen by the various species and stages of development as observed in the field and may be regarded as explaining the distribution of the grasshoppers in their natural environment.

1880		1881		1882		1883		1884		1885		1886		1887		1888		1889		1890		1891		1892		1893		1894		1895		1896		1897		1898		1899		1900		1901		1902		1903		1904		1905		1906		1907		1908		1909		1910		1911		1912		1913		1914		1915		1916		1917		1918		1919		1920		1921		1922		1923		1924		1925		1926		1927		1928		1929		1930		1931		1932		1933		1934		1935		1936		1937		1938		1939		1940		1941		1942		1943		1944		1945		1946		1947		1948		1949		1950		1951		1952		1953		1954		1955		1956		1957		1958		1959		1960		1961		1962		1963		1964		1965		1966		1967		1968		1969		1970		1971		1972		1973		1974		1975		1976		1977		1978		1979		1980		1981		1982		1983		1984		1985		1986		1987		1988		1989		1990		1991		1992		1993		1994		1995		1996		1997		1998		1999		2000		2001		2002		2003		2004		2005		2006		2007		2008		2009		2010		2011		2012		2013		2014		2015		2016		2017		2018		2019		2020		2021		2022		2023		2024		2025		2026		2027		2028		2029		2030		2031		2032		2033		2034		2035		2036		2037		2038		2039		2040		2041		2042		2043		2044		2045		2046		2047		2048		2049		2050		2051		2052		2053		2054		2055		2056		2057		2058		2059		2060		2061		2062		2063		2064		2065		2066		2067		2068		2069		2070		2071		2072		2073		2074		2075		2076		2077		2078		2079		2080		2081		2082		2083		2084		2085		2086		2087		2088		2089		2090		2091		2092		2093		2094		2095		2096		2097		2098		2099		2100		2101		2102		2103		2104		2105		2106		2107		2108		2109		2110		2111		2112		2113		2114		2115		2116		2117		2118		2119		2120		2121		2122		2123		2124		2125		2126		2127		2128		2129		2130		2131		2132		2133		2134		2135		2136		2137		2138		2139		2140		2141		2142		2143		2144		2145		2146		2147		2148		2149		2150		2151		2152		2153		2154		2155		2156		2157		2158		2159		2160		2161		2162		2163		2164		2165		2166		2167		2168		2169		2170		2171		2172		2173		2174		2175		2176		2177		2178		2179		2180		2181		2182		2183		2184		2185		2186		2187		2188		2189		2190		2191		2192		2193		2194		2195		2196		2197		2198		2199		2200		2201		2202		2203		2204		2205		2206		2207		2208		2209		2210		2211		2212		2213		2214		2215		2216		2217		2218		2219		2220		2221		2222		2223		2224		2225		2226		2227		2228		2229		2230		2231		2232		2233		2234		2235		2236		2237		2238		2239		2240		2241		2242		2243		2244		2245		2246		2247		2248		2249		2250		2251		2252		2253		2254		2255		2256		2257		2258		2259		2260		2261		2262		2263		2264		2265		2266		2267		2268		2269		2270		2271		2272		2273		2274		2275		2276		2277		2278		2279		2280		2281		2282		2283		2284		2285		2286		2287		2288		2289		2290		2291		2292		2293		2294		2295		2296		2297		2298		2299		2300		2301		2302		2303		2304		2305		2306		2307		2308		2309		2310		2311		2312		2313		2314		2315		2316		2317		2318		2319		2320		2321		2322		2323		2324		2325		2326		2327		2328		2329		2330		2331		2332		2333		2334		2335		2336		2337		2338		2339		2340		2341		2342		2343		2344		2345		2346		2347		2348		2349		2350		2351		2352		2353		2354		2355		2356		2357		2358		2359		2360		2361		2362		2363		2364		2365		2366		2367		2368		2369		2370		2371		2372		2373		2374		2375		2376		2377		2378		2379		2380		2381		2382		2383		2384		2385		2386		2387		2388		2389		2390		2391		2392		2393		2394		2395		2396		2397		2398		2399		2400		2401		2402		2403		2404		2405		2406		2407		2408		2409		2410		2411		2412		2413		2414		2415		2416		2417		2418		2419		2420		2421		2422		2423		2424		2425		2426		2427		2428		2429		2430		2431		2432		2433		2434		2435		2436		2437		2438		2439		2440		2441		2442		2443		2444		2445		2446		2447		2448		2449		2450		2451		2452		2453		2454		2455		2456		2457		2458		2459		2460		2461		2462		2463		2464		2465		2466		2467		2468		2469		2470		2471		2472		2473		2474		2475		2476		2477		2478		2479		2480		2481		2482		2483		2484		2485		2486		2487		2488		2489		2490		2491		2492		2493		2494		2495		2496		2497		2498		2499		2500		2501		2502		2503		2504		2505		2506		2507		2508		2509		2510		2511		2512		2513		2514		2515		2516		2517		2518		2519		2520		2521		2522		2523		2524		2525		2526		2527		2528		2529		2530		2531		2532		2533		2534		2535		2536		2537		2538		2539		2540		2541		2542		2543		2544		2545		2546		2547		2548		2549		2550		2551		2552		2553		2554		2555		2556		2557		2558		2559		2560		2561		2562		2563		2564		2565		2566		2567		2568		2569		2570		2571		2572		2573		2574		2575		2576		2577		2578		2579		2580		2581		2582		2583		2584		2585		2586		2587		2588		2589		2590		2591		2592		2593		2594		2595		2596		2597		2598		2599		2600		2601		2602		2603		2604		2605		2606		2607		2608		2609		2610		2611		2612		2613		2614		2615		2616		2617		2618		2619		2620		2621		2622		2623		2624		2625		2626		2627		2628		2629		2630		2631		2632		2633		2634		2635		2636		2637		2638		2639		2640		2641		2642		2643		2644		2645		2646		2647		2648		2649		2650		2651		2652		2653		2654		2655		2656		2657		2658		2659		2660		2661		2662		2663		2664		2665		2666		2667		2668		2669		2670		2671		2672		2673		2674		2675		2676		2677		2678		2679		2680		2681		2682		2683		2684		2685		2686		2687		2688		2689		2690		2691		2692		2693		2694		2695		2696		2697		2698		2699		2700		2701		2702		2703		2704		2705		2706		2707		2708		2709		2710		2711		2712		27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Table Showing Reactions to Environmental Stimuli.

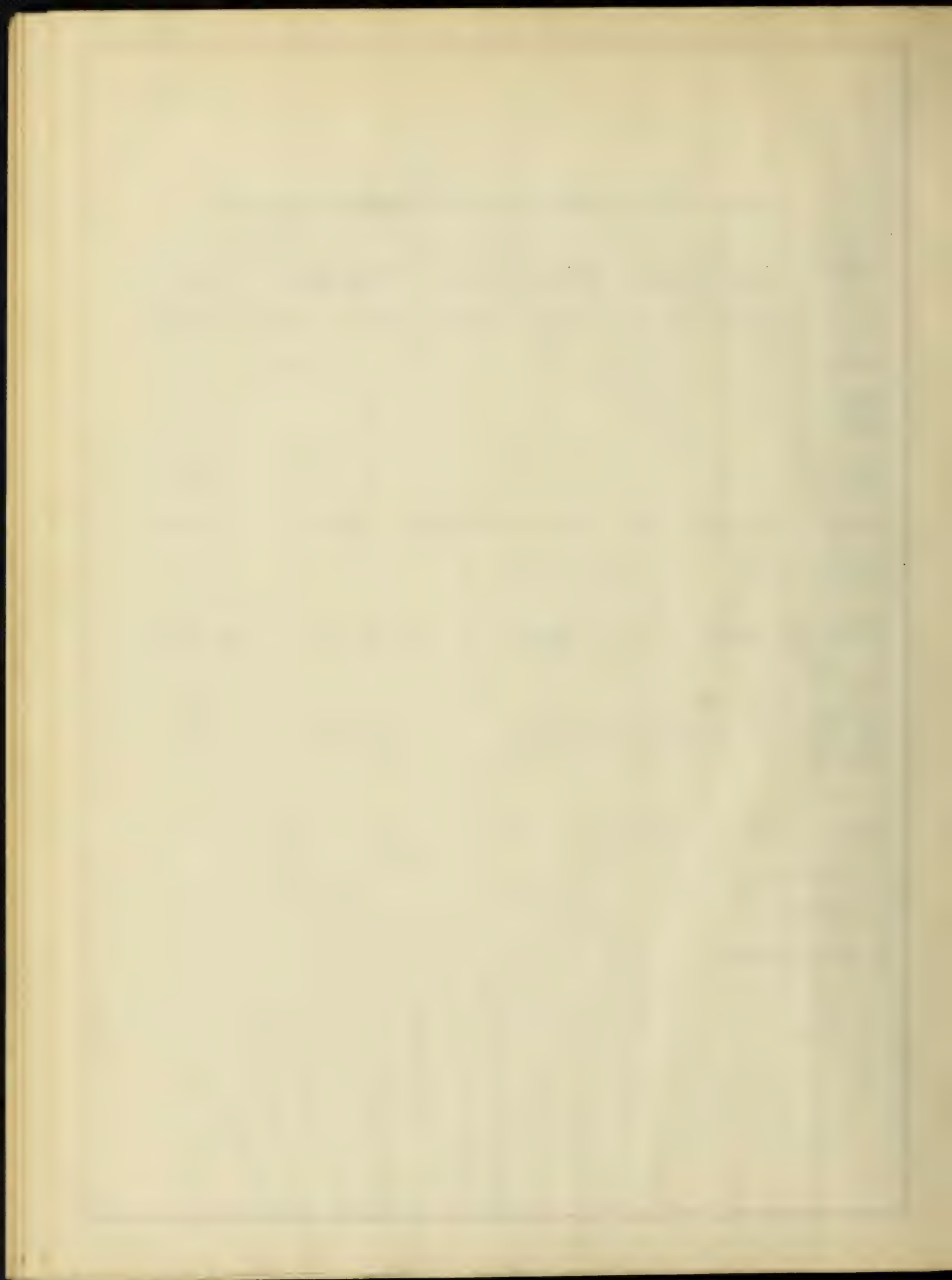
Stimuli	L. difformis		M. pennsylvanicus		D. varians		L. granulata	
	Fresh margin		Sweet clover		Clay bank		In soil	
	Adults		Adults		Adults		Adults	
Light	N	N	I	N	I	N	I	I
Intensity	N	N	P	N	P	P	P	I
Direction	N	N	I	N	P	P	P	N
Colors	(Orange & red)		(Green & yellow)		(Brown)		(Black)	
Rock surfaces	I	N	I	N	I	I	I	N
Temperature	(10 warm)		(10 warm)		(10 warm)		(10 warm)	
Gravitation	I	N	I	N	I	I	I	N
Preference for dry air	I	I	P	N	I	I	I	I

Explanation of symbols:-

I- Indifferent

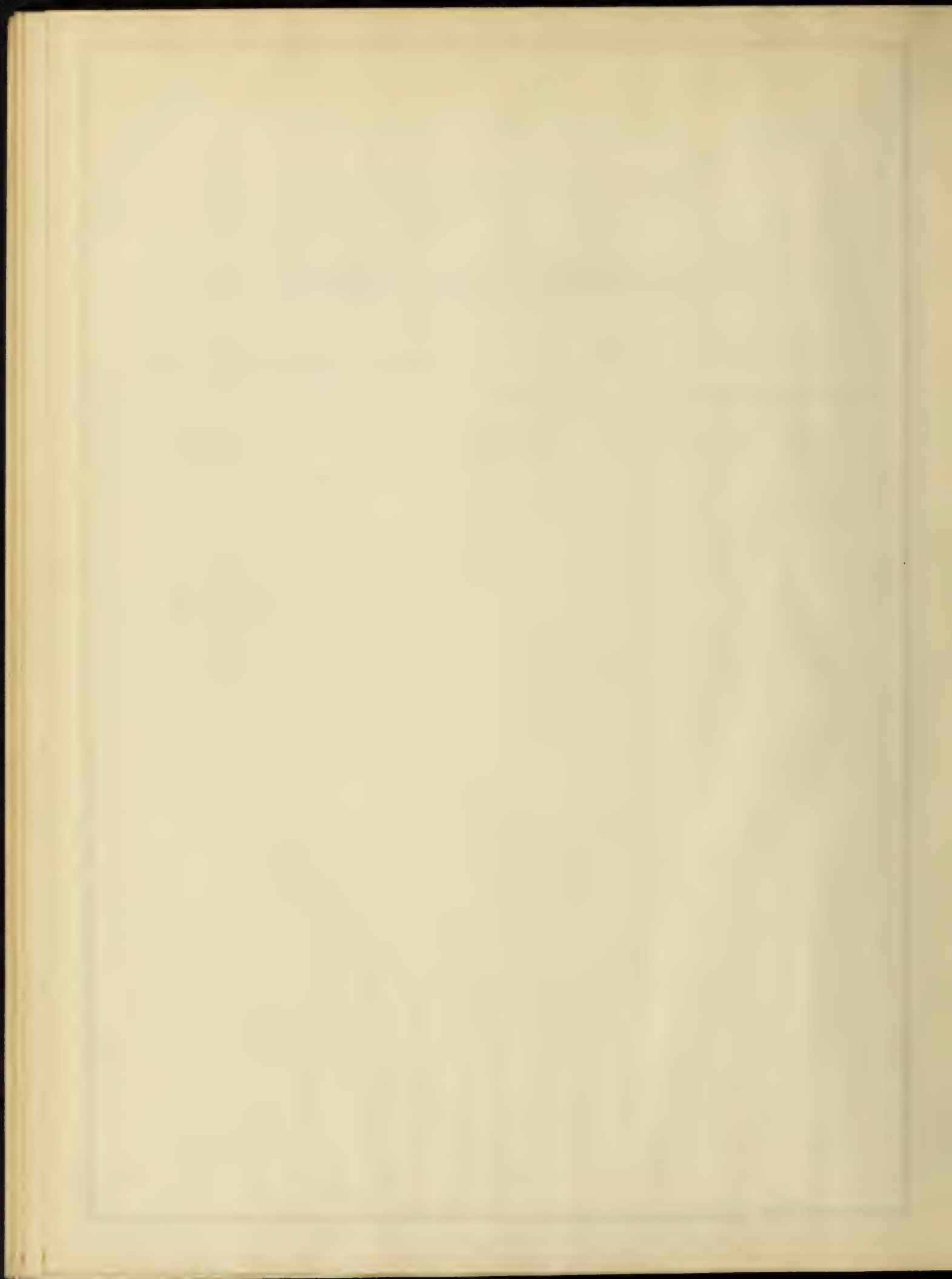
N- Negative

P- Positive



VI. ACKNOWLEDGMENT AND BIBLIOGRAPHY.

To Dr. T. E. Stolford my sincere thanks are due both for many valuable suggestions and criticisms and for the encouragement and inspiration which have made the work enjoyable.



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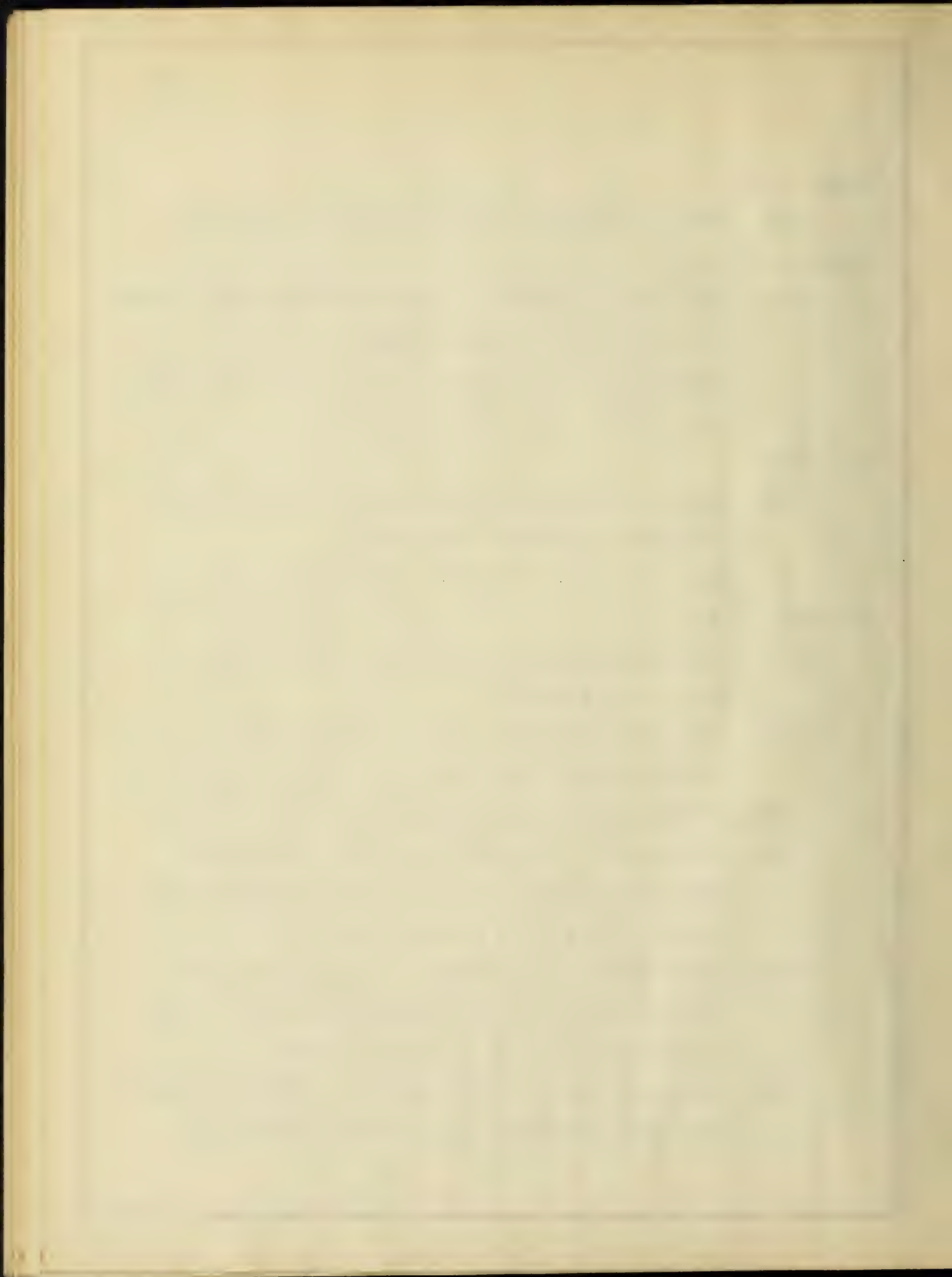
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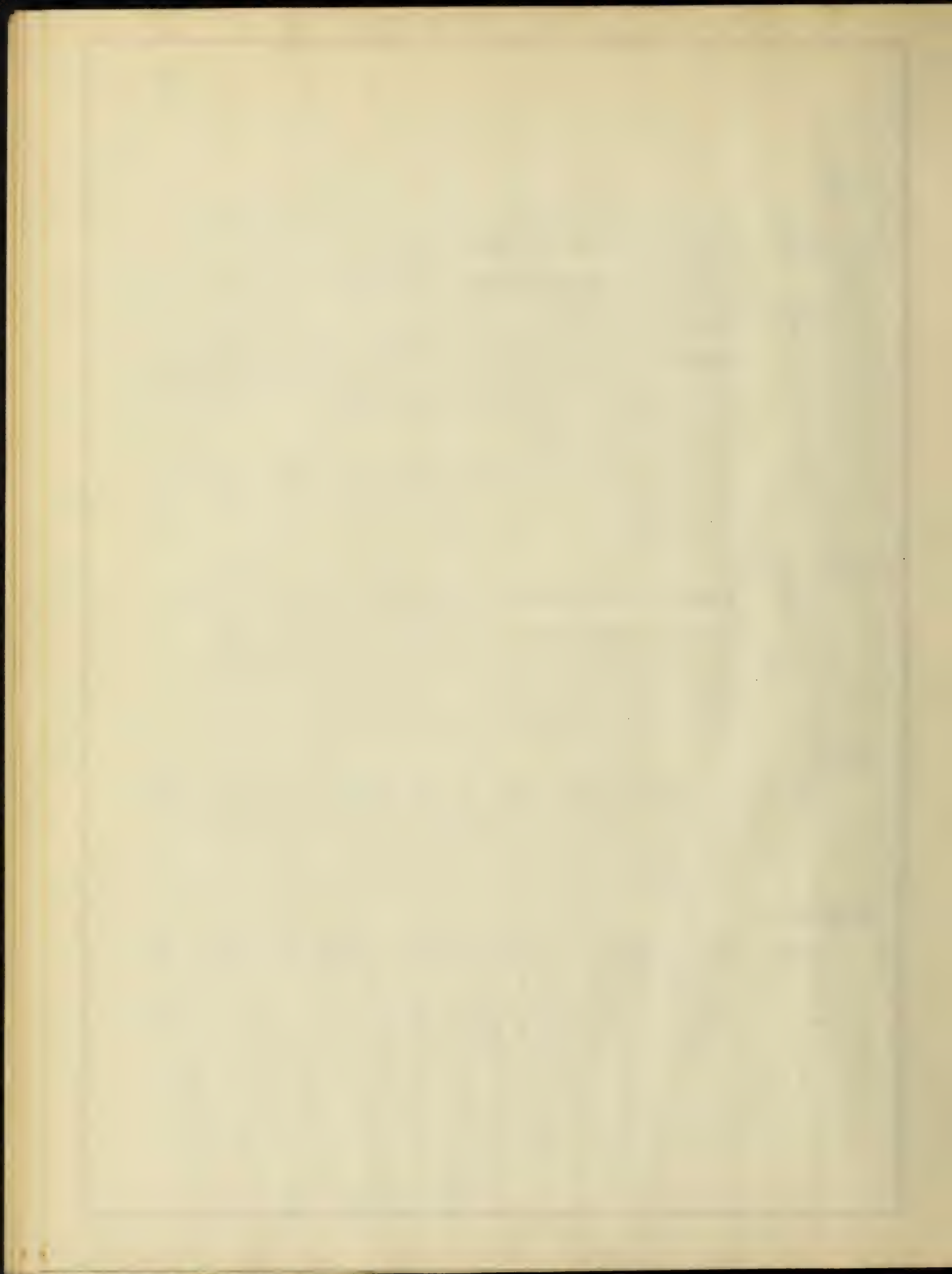


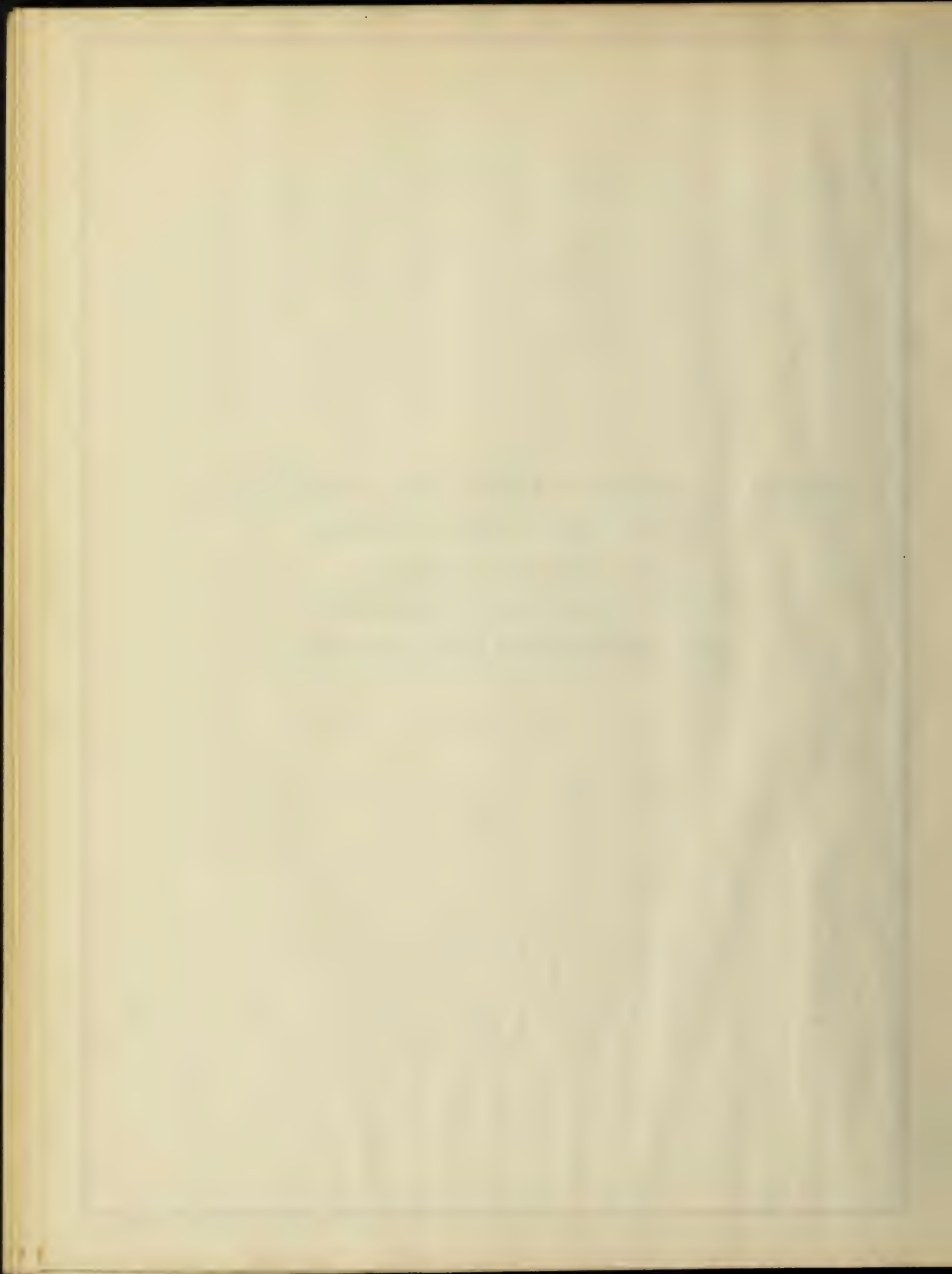
Diagram 1.-- Diagrammatic profile of the stations studied.

A-B, The Sweet Clover Association.

B-C, The Clay Bank Association.

C-D, The Brook Margin Association.

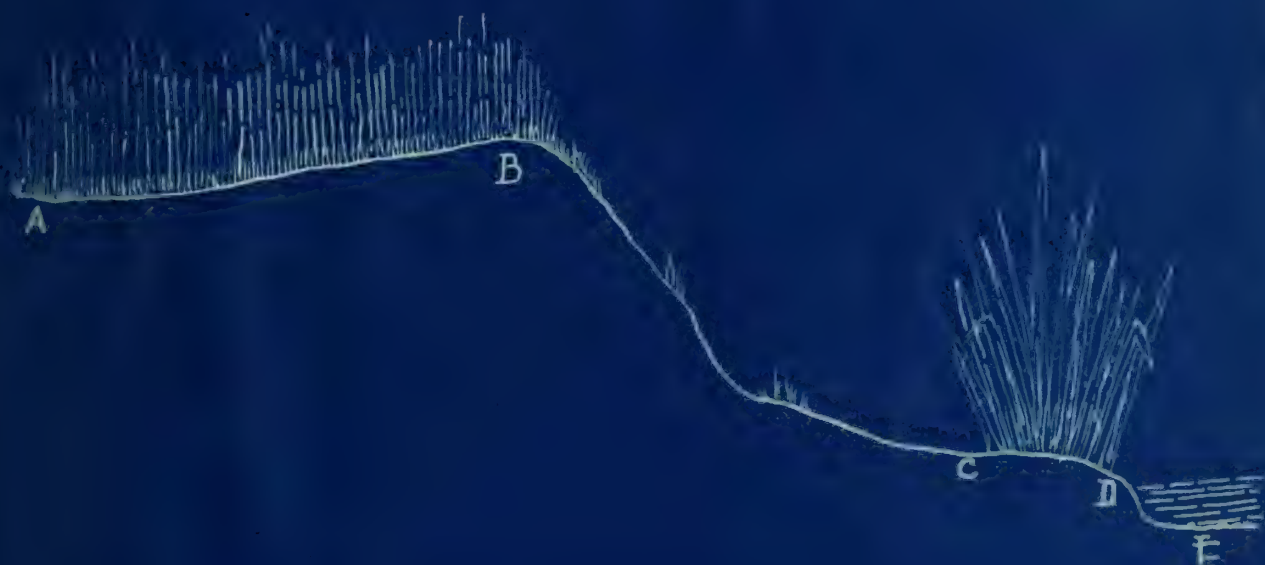
E- , The Lowery Marsh Association.



Diagrammatic Profile

of

Stations Studied.



A-B Sweet Clover Association.

B-C Clay-Bank "

C-D Stream Margin "

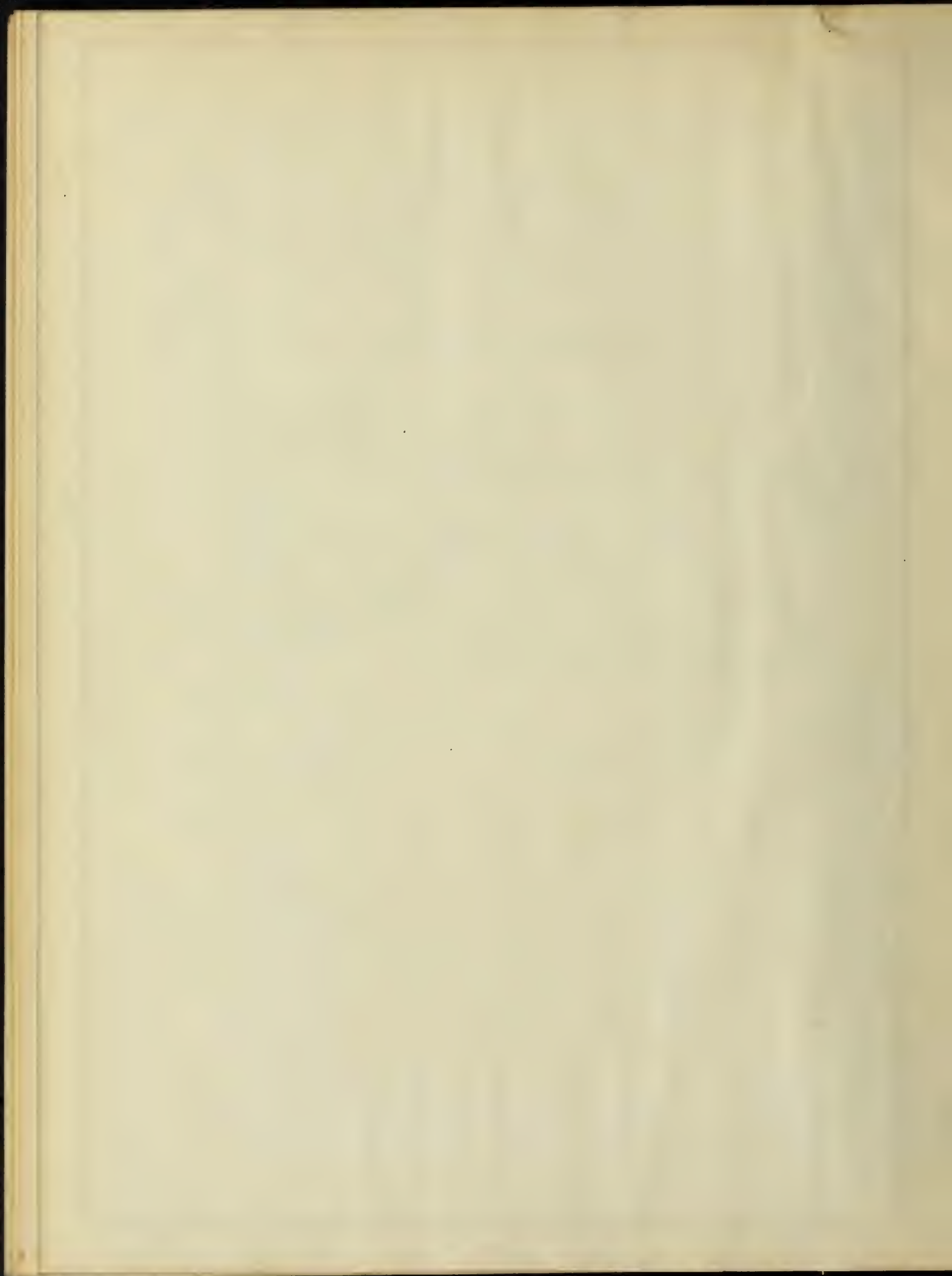
E- Marsh "

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Explanation of Plate 1.

Fig. 1 - The Clay Bank, a type of situation selected by Dissosteira carolina.

Fig. 2 - A view showing a dry, barren path. At the right is the edge of the Br. & L. Association. The vegetation at the lower left corner belongs to the Sweet Clover Association.



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1



2

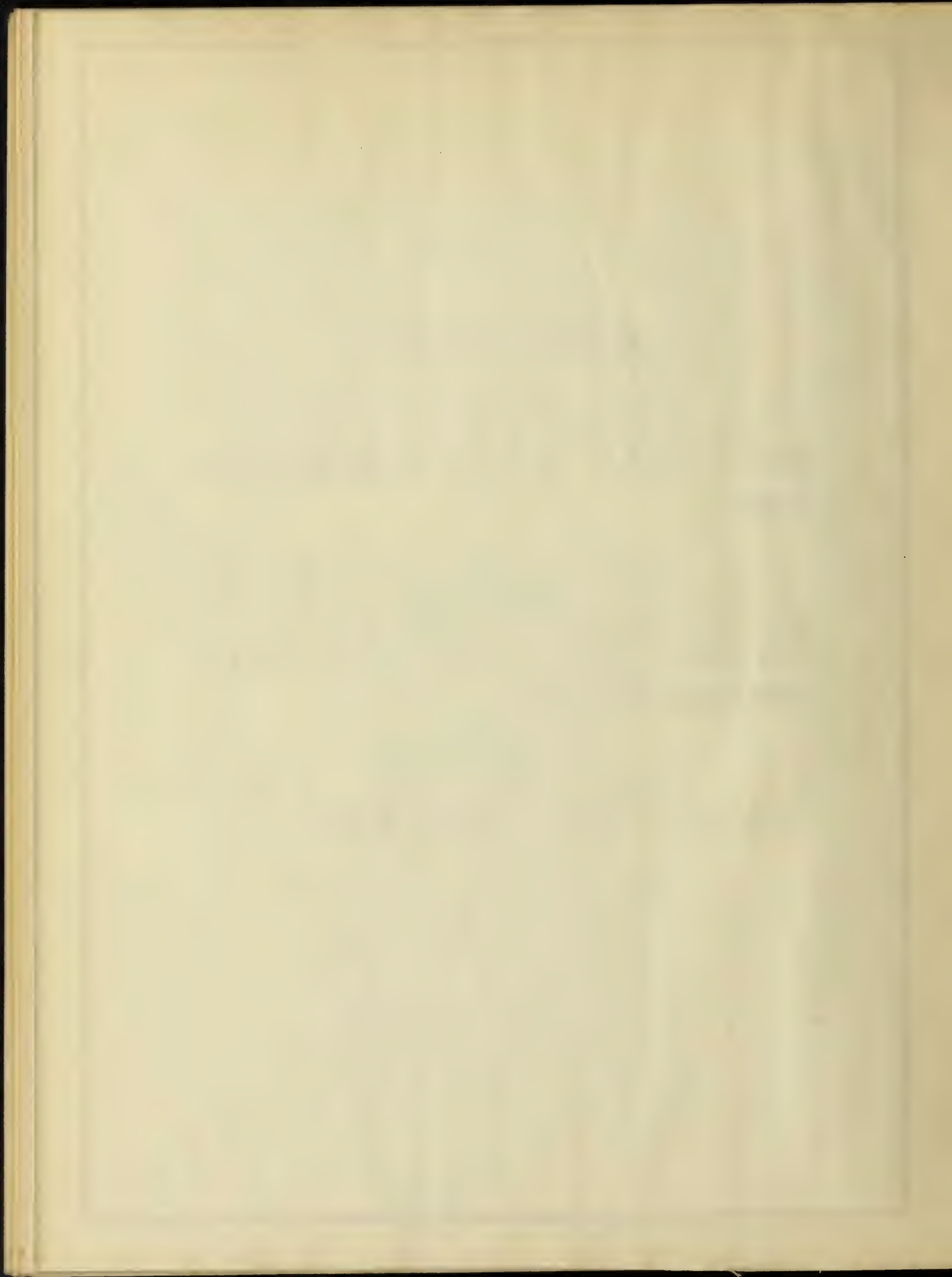


Explanatory of Plate II.

Fig. 3 - is a detailed view of the Sweet
Clover Association, the habitat of Melanoplus venar
rubens.

Fig. 4 - is a detailed view of the Brook
Larva Association showing a growth of grass and smart
weed shaded by willows. A typical habitat chosen by
Melanoplus differentialis.

Fig. 5 - is a detailed view of the Lowland
Marsh. typical habitat of Tettix granulata.





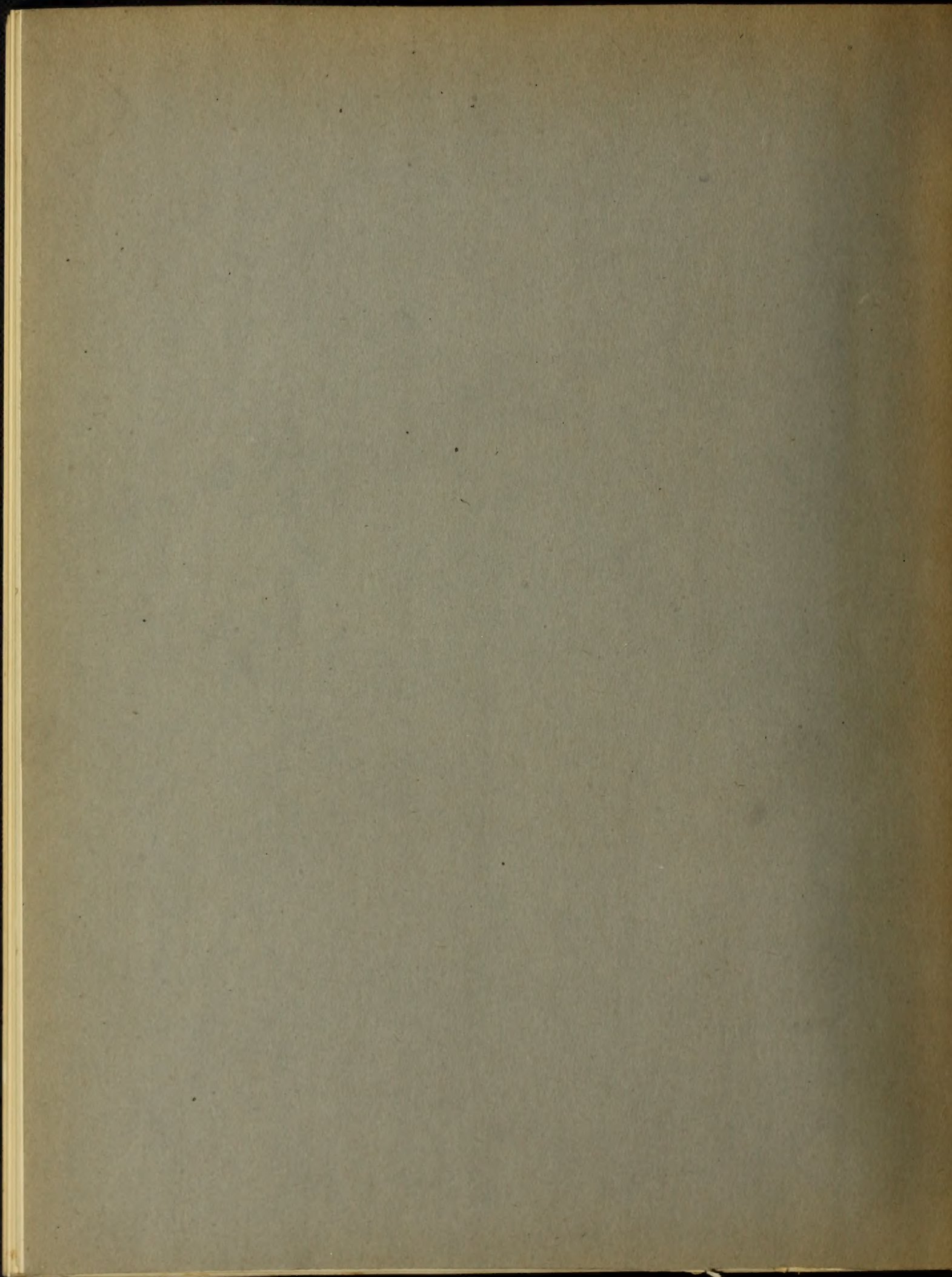
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4



5



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